FRONT PAGE

PROJECT FINAL REPORT

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Project acronym: FIRESENSE

Project title: "Fire Detection and Management through a Multi-Sensor Network for the Protection of Cultural Heritage Areas from the Risk of Fire and Extreme Weather Conditions"

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4.1 Final publishable summary report

4.1.1 Executive summary

FIRESENSE "*Fire Detection and Management through a Multi-Sensor Network for the Protection of Cultural Heritage Areas from the Risk of Fire and Extreme Weather Conditions*" (FP7-ENV-2009-1-244088-FIRESENSE) is a Specific Targeted Research Project of the European Union's 7th Framework Programme *Environment (including Climate Change)*. The project started on December 1, 2009, and finished on February 28, 2013.

One of the main causes of destruction of archaeological and cultural heritage sites, especially in the Mediterranean region, is wildfires. These sites, treasured and tended for long periods of time, are usually surrounded by old and valuable vegetation or situated close to forest regions. The increase in seasonal temperatures has caused an explosion in the number of self-ignited fires in forested areas, which fanned by winds and fuelled by dry vegetation become disastrous. Extreme weather conditions such as storms or floods also pose greats risk for these sites.

Beyond taking precautionary measures to avoid forest fires, early warning and immediate response to a fire break out is the only way to avoid human losses and environmental and cultural heritage damage. Although several technologies based on different sensors have been proposed for wildfire surveillance, the majority of existing fire detection systems does not realize the full potential of state-of-the-art technologies due to the lack of an integrated approach.

In the context of the FIRESENSE project, an automatic early warning system integrating multiple sensors to remotely monitor areas of archaeological and cultural interest for the risk of fire and extreme weather conditions was developed. The system integrates various sensors including optical cameras, infrared cameras at different wavebands, passive infrared (PIR) sensors, a wireless sensor network of temperature and humidity sensors and local weather stations on the deployment sites. The signals and measurements collected from these sensors are transmitted to the control centre, which employs intelligent computer vision and pattern recognition algorithms as well as data fusion techniques to automatically analyze and combine sensor information and detect the presence of fire or smoke.

The control centre is capable of generating automatic warning signals for smoke/flame detection and abrupt temperature rise. Moreover, by reading weather data from official meteorological services as well as from local weather stations, it is can also issue alerts in case of extreme weather conditions. The control centre interface allows monitoring of the site through the cameras, display of maps of the area with multiple layers, manipulation of cameras and sensors and provision of video and statistical data on user demand. Moreover, it can estimate the propagation of the fire based on the fuel model of the area, the local weather conditions and the ground morphology. The estimated fire propagation is visualized on a Google Earth based 3D interface. This information is extremely valuable for efficient fire management by fire fighting forces.

The FIRESENSE control centre adopts a modular architecture, which allows easy integration of different sensors and processing modules. It integrates novel algorithms and techniques for fire and smoke detection based on visible and infrared data, WSN-based fire detection, fusion of multisensory data, vegetation classification and fire propagation estimation. It also adopts a cluster-based WSN architecture implementing novel routing and activity scheduling protocols to enhance network reliability and energy efficiency.

The FIRESENSE system was demonstrated and evaluated in five cultural heritage sites in the Mediterranean area: the sanctuary of Kabeirion in Thebes, Greece, the ancient city of Rhodiapolis in Antalya, Turkey, the Dodge Hall building in Istanbul, Turkey, the Roman Temple of Water in Djebel Zaghouan, Tunisia and Monteferrato-Galceti Park in Prato, Italy. Numerous controlled fire tests were organized in several sites to assess system functionalities and evaluate system performance. The system achieved high detection rates and has successfully detected two real fires in Rhodiapolis in September and October 2012.

4.1.2 Summary of project context and objectives

The challenge

One of the main causes of destruction of archaeological and cultural heritage sites, especially in the Mediterranean region, is wildfires. These sites, treasured and tended for long periods of time, are usually surrounded by old and valuable vegetation or situated close to forest regions. The increase in seasonal temperatures has caused an explosion in the number of self-ignited fires in forested areas, which when fanned by winds and fuelled by dry vegetation become disastrous. In addition, arson events have been repeatedly reported, while common causes of unintentional fires are human carelessness and lightning strikes. Extreme weather conditions such as storms or floods also pose great risks for these sites.

In the summer of 2007, Ancient Olympia, an UNESCO world heritage site and the birthplace of the ancient Olympic Games, was seriously endangered by a fast-moving wildfire. The fire reached the hill overlooking ancient Olympia and it was contained just before entering the archaeological site, but not before reaching a historic pine-covered hilltop above the renowned stadium. Flames licked the edges of the original Olympic stadium and scorched the yard of the museum, home to one of Greece's greatest archaeological collections. The surrounding forest was destroyed. Similar fires have cause significant damages in archaeological areas and treasures all over the Mediterranean, especially during summer months.

Figure 1: Ancient Olympia on fire, August 2007

Beyond taking precautionary measures to avoid forest fires, early warning and immediate response to a fire break out is the only way to avoid human losses and environmental and cultural heritage damages. Thus, the most important goal in fire surveillance is quick and reliable detection and localization of fire, since it is much easier to suppress a fire when the location of the ignition point is known and while the fire is at an early stage. An automatic fire detection system relying on multi-sensor networks should be able to provide early fire warning and also collect information about the location and spread of fire to facilitate efficient fire management. Based on this information, the firefighting staff can be guided on target to contain the fire before it reaches cultural heritage sites and to suppress it quickly by utilizing the appropriate equipment and vehicles.

The majority of commercial wildfire surveillance systems do not realize the full potential offered by available technologies due to the lack of an integrated approach. Most of the systems use visible range cameras mounted on watch towers to monitor large forested areas. Some systems utilize infrared cameras, which are usually much more expensive compared to regular pan-tilt-zoom (PTZ) cameras and their range may be limited. Few systems employ wireless temperature sensor networks, which can provide real-time feedback for the detection and evolution of fire. All the aforementioned approaches have their own advantages and limitations. What is currently missing is an integrated solution that will combine the outputs of different sensors to increase the detection accuracy and overcome individual sensor limitations.

The goal

FIRESENSE aims to develop an automatic early warning system integrating multiple sensors to remotely monitor areas of archaeological and cultural interest for the risk of fire and extreme weather conditions. FIRESENSE will take advantage of recent advances in multi-sensor surveillance technologies by employing both optical and infrared cameras to monitor the site and the surrounding area as well as a wireless sensor network capable of measuring different environmental parameters (e.g. temperature, humidity). The signals and measurements collected from these sensors will be transmitted to a monitoring center, which will employ intelligent computer vision and pattern recognition algorithms as well as data fusion techniques to automatically analyze and combine sensor information. The control centre will be capable of generating automatic warning signals whenever a dangerous situation arises, i.e. when fire or smoke is detected. Moreover, the system will read weather data from official meteorological services as well as from local weather stations installed at the site and will issue alerts in case of extreme weather conditions. It will also provide real-time information about the evolution of the fire based on wireless sensor network data. Furthermore, it will be able to estimate the propagation of the fire based on the fuel model of the area and other important parameters such as wind speed and direction and ground morphology. Finally, the estimated fire propagation will be visualized on a 3D Geographic Information System (GIS) environment.

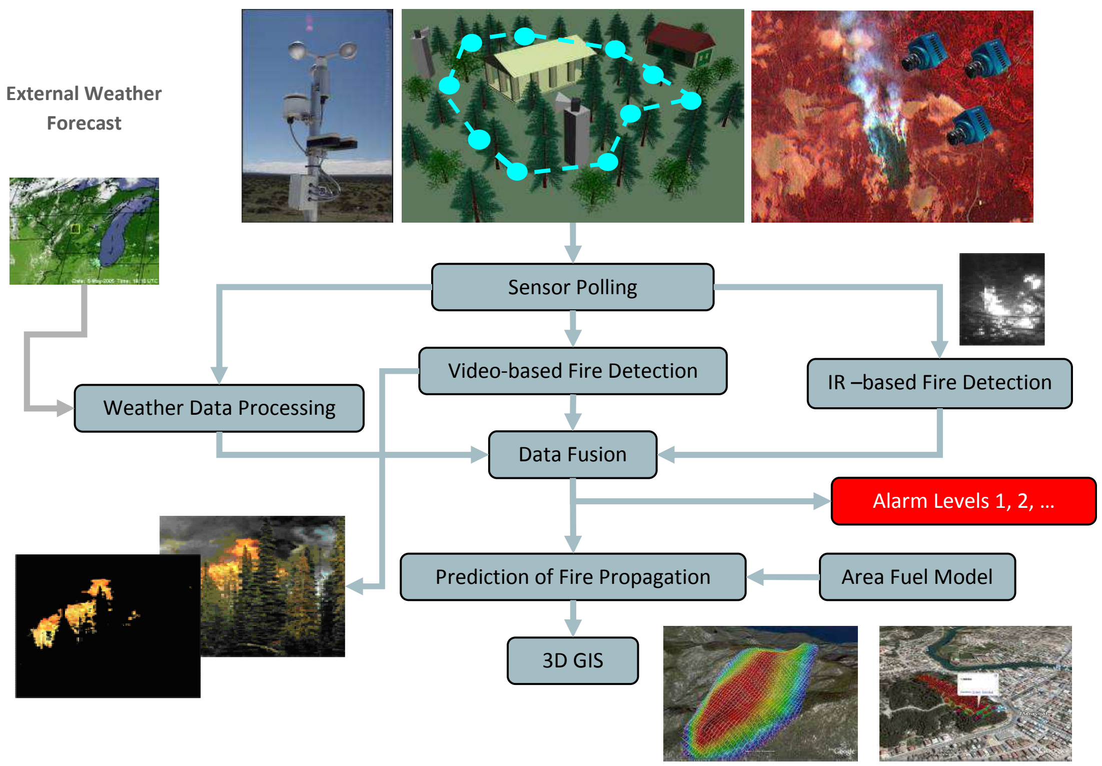

Figure 2: Architecture of the FIRESENSE system.

The objectives

To main S&T objectives of FIRESENSE are the following:

- Identification of user requirements and system design
  - Extensive survey of state-of-the-art algorithms, technologies and systems related to FIRESENSE including EU and national research projects.

    - Establishment of an international group of users including people related to fire suppression and cultural heritage preservation and launch of international survey for the identification of user requirements.
    - Definition of FIRESENSE system requirements based on the state-of-the-art survey, the user requirements and technical, economical and legal constraints.
- Smoke and fire detection based on cameras and WSN sensors
    - Development of novel algorithms for fire and smoke detection based on visible cameras.
    - Development of novel techniques for thermal data processing using infrared cameras at different wavebands. Development of low-cost pyroelectric infrared (PIR) sensor based system for indoor fire detection.
    - Collection and analysis of weather data from local weather stations and official sources.
    - Definition of WSN architecture and related communication protocols; definition of constraints and requirements for the network topology and the network node/gateway hardware/software.
    - Hardware and software design, development and integration of sensor nodes, WSN gateways and housing. Design and development of communication protocols, routing algorithms and network topology for maximizing the lifetime of the WSN.
    - Establishment of guidelines and test procedures for WSN deployment and maintenance.
- Multi-sensor data fusion
    - Development of novel data fusion techniques for the combination of data from multiple sensors to detect fire and smoke.
    - Provision of different alarm levels for cases of temperature rise, detection of smoke or fire, extreme weather conditions, etc based on the result of multi-sensor data fusion.
- Estimation and visualization of fire propagation
    - Estimation of vegetation distribution and relevant fuel model parameters in monitored areas based on satellite images, pre-existing land cover information or ground surveys.
    - Estimation of fire propagation based on the semi-empirical BEHAVE model and examination of physical and hybrid models for fire spread calculations.
    - Development of user friendly GIS-based platform for 2D/3D visualization of the estimated fire propagation.
- Development of FIRESENSE Control Centre
    - The control centre will provide various functionalities to the end users such as visual and acoustic alarms in case of fire/smoke detection and extreme weather conditions, easy access to camera streams and sensor measurements, manipulation of cameras and sensors, video on demand, maps for location and visualisation, visualization of fire propagation estimation, etc through a user friendly interface.
- System installation, integration and demonstration
    - The system will be demonstrated in five cultural heritage sites in the Mediterranean area: the sanctuary of Kabeirion in Thebes, Greece, the ancient city of Rhodiapolis in Antalya, Turkey, the Dodge Hall building in Istanbul, Turkey, the Roman Temple of Water in Djebel Zaghouan, Tunisia and Monteferrato-Galceti Park in Prato, Italy.

- System evaluation
  - Development of methodological framework for assessing the performance of the proposed system, in terms of covering the user requirements and expectations.
  - Laboratory testing of system components and functionalities.
  - Organization of real fire experiments for data collection and system evaluation.
  - Evaluation of the final system in terms of technical performance and user acceptance and validation against initial requirements.
- FIRESENSE dissemination and exploitation
  - Dissemination of project information and results through the project website and project brochure, publications, media releases, meeting with stakeholders, etc.
  - Education of inhabitants through a series of lectures aiming at making people living close to test sites conscious about the importance of their surrounding area.
  - Organization of Workshop to demonstrate and disseminate project results.
  - Market analysis and development of strategy for exploiting project results beyond the life of the project.

Figure 3: The FIRESENSE pilot sites: Temple of Water (a, b), Sanctuary of Kabeirion (c), ancient city of Rhodiapolis (d, e), Galceti Park (f, g) and Dodge Hall (i).

4.1.3 Main S&T results/foregrounds

In the context of the FIRESENSE project, an automatic early warning system integrating multiple sensors to remotely monitor areas of archaeological and cultural interest for the risk of fire and extreme weather conditions was developed. The system integrates various sensors including optical cameras, infrared cameras at different wavelengths, passive infrared (PIR) sensors, a wireless sensor network of temperature and humidity sensors as well as local weather stations on the deployment sites. The signals and measurements collected from these sensors are transmitted to the control centre, which employs intelligent computer vision and pattern recognition algorithms as well as data fusion techniques to automatically analyze and combine sensor information. The control centre is capable of generating automatic warning signals for smoke/flame detection, abrupt temperature rise and extreme weather conditions. It also allows inspection of the site through the cameras, manipulation of cameras and sensors and provision of statistical data on user demand. Moreover, it estimates the propagation of the fire based on the fuel model of the area, the local weather conditions and the ground morphology. Finally, the estimated fire propagation can be visualized on a Google Earth based 3D interface. In the following, the main science and technology results of the FIRESENSE project are summarized per workpackage.

WP2: Requirements Identification and System Specification

The main S&T results of WP2 are a) the identification of user requirements for an early warning system for the protection of cultural heritage areas from the risk of fire and b) the specification of the FIRESENSE system architecture, components and interfaces.

Analysis of the state of the art

An extensive state-of-the-art survey on technologies related to FIRESENSE was delivered in the early months of the project. Different sensor technologies for surveillance and monitoring were investigated (visible spectrum and IR cameras, PIR and smoke sensors, wireless sensor networks, meteorological sensors). Visible spectrum fire/smoke detection algorithms were examined and their advantages and disadvantages were identified. A survey on the usage of infrared bands for fire detection was also included and possible features in each band were identified. WSN technologies achieving energy efficient communication were also examined and possible network topologies along with factors affecting them were investigated. Methods for fusing data from different sensors were also studied. Different fire spread models and factors affecting the spread were surveyed and existing fire propagation visualization technologies were identified. Finally, existing commercial indoor and forest fire detection systems and standards were studied and related EU projects were reviewed. Advantages and disadvantages of state-of-the-art techniques/systems/projects were indentified and were used for system specification.

Identification of user requirements

The review of state-of-the-art technologies and available systems is very important for system design but equally important are the experience, needs, ideas and concerns of potential users. To identify user requirements, an international group of users was established including stakeholders involved in the preservation of cultural heritage sites (archaeologists, curators, ephorates, local authorities, etc.) and organizations involved in fire prevention/fighting, forest protection and civil protection in Greece, Turkey, Italy and Tunisia. Two user questionnaires were designed aiming at people related to fire suppression/ environmental protection and cultural heritage preservation respectively. Issues concering system design, functionalities, performance, installation and maintenance as well as the status of similar systems in cultural heritage sites in different countries were covered.

User requirements were defined through a two-stage process: first, conclusions/ information were drawn from the state-of-the-art survey and the analysis of user questionnaires. Then, a list of conclusions drawn from interviews and e-mail communications with experts and discussions among partners was generated. The outputs of this process were used to synthesize the final list of requirements including a) technical / operational requirements (cameras, sensors, communication links, power, software modules, interfaces, and maintenance), b) requirements associated with system installation and cost and c) environmental constraints.

The initial system requirements were updated during the final months of the project based on the feedback received by experts. User feedback was received through questionnaires evaluating system performance and functionalities, which were filled during system demonstration activities by users employed in fire service, forest service, cultural heritage organizations, local authorities and research institutions. Feedback from experts in fire prevention, suppression and management was also received through discussions and delivery of brief evaluation reports.

Field tests

Numerous field tests with real controlled fires were conducted in different settings using visible spectrum cameras and infrared cameras on different wavebands. These tests provided valuable information for recognizing potential problems and vulnerabilities of the system and allowed selection of the cameras that are suitable for FIRESENSE. In addition, they resulted in the creation of a large database of video recordings, which were also used for algorithm testing.

System specification

The components and functionalities of the FIRESENSE system were designed taking into consideration: a) user requirements, b) analysis of the state-of-the-art technologies and systems, c) results of field tests and d) various technical, economical and legal constraints. System architecture, specifications for different sensors and communication links, specifications for software modules (video-based fire/smoke detector, IR-based fire detector, WSN sensor and gateway software, data fusion and alarm generation, estimation & visualization of fire propagation) and specifications for control centre components, functionalities and interfaces were defined. Moreover, detailed plans for the deployment of the FIRESENSE system in the five pilot sites were prepared (e.g. sensors and communication links to be used, installation plans, power supply, possible problems, etc) and a set of use cases corresponding to different real world fire detection scenarios was identified.

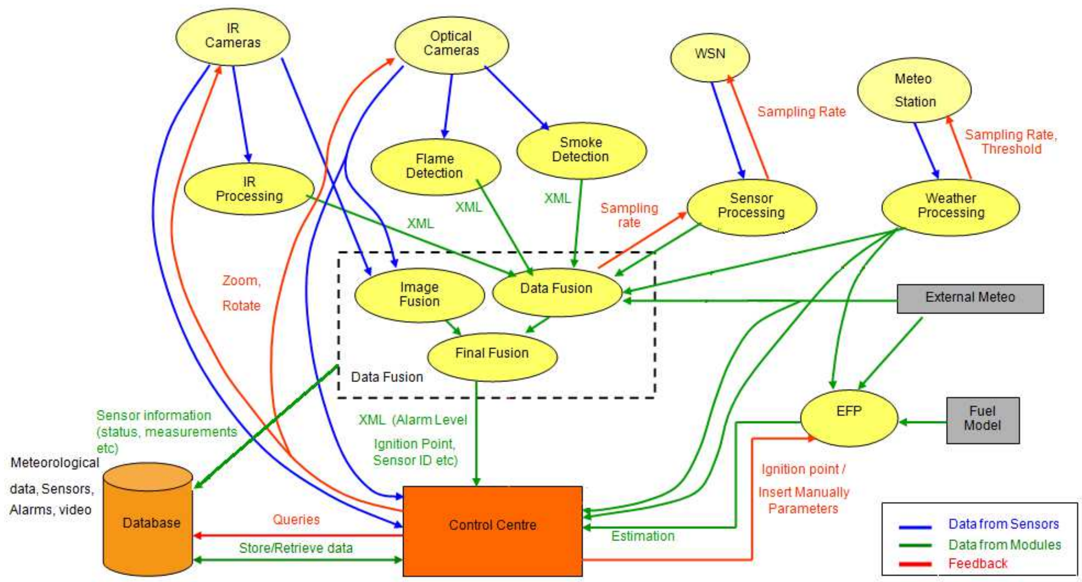

Figure 4: FIRESENSE system architecture. The various system components (sensors, software modules, etc) and their interaction are illustrated.

WP3: Fire-Smoke Detection and Weather Data Collection

The main S&T result of WP3 is the development of algorithms and software for fire and smoke detection based on optical and IR cameras. The developed software enables early detection of fires in large open areas and can be used for the protection of forests and cultural heritage areas, as well as for the detection of fires in landfills, industrial areas (chemical fires, warehouses) and military training areas.

Computer vision based flame detection

Optical cameras and video-based algorithms provide an effective and low cost solution for the detection of flames at an early stage. However, video-based flame detection systems are affected by several limitations that challenge their performance such as the presence of sun reflections, car lights, bad lighting conditions, poor image quality, movements of fire-like coloured objects, etc. To overcome the aforementioned drawbacks, partners focused on improving existing algorithms and developing three new techniques for flame detection. The developed algorithms offer increased detection rates and lower false positive ratios compared to the literature.

BILKENT developed a covariance matrix based fire detection method for video sequences. The algorithm divides the video into spatiotemporal blocks and uses covariance-based features extracted from these blocks to detect fire. Both the spatial and the temporal characteristics of flame colored regions are exploited. Unlike other algorithms used for similar tasks, the proposed method does not use background subtraction, which means that it does not require a stationary camera for the detection of moving flame regions and can, therefore, be also used with moving cameras. This is an important advantage because fixed cameras may sway because of the wind or a PTZ camera can slowly pan an area of interest to detect fire.

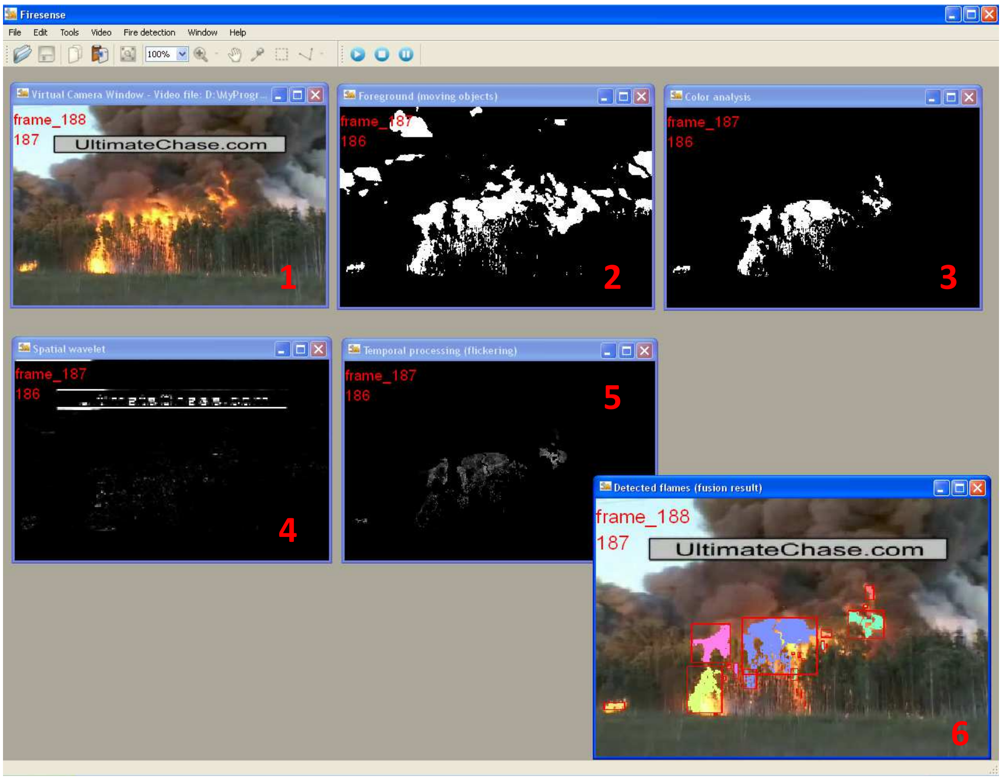

Figure 5: Example of CERTH's flame detection algorithm results: 1) input video frame, 2) estimated foreground i.e. detected moving objects, 3) result of color analysis (detection of regions with fire-like color), 4) result of spatial analysis, 5) result of temporal analysis (flame flickering detection), 6) result of feature fusion, i.e. detected flames. Red rectangles indicate the regions of the image where flame was detected. Detected flame blobs are illustrated as coloured regions.

CERTH developed a video based flame detection algorithm, which initially applies background subtraction and colour analysis to identify candidate flame regions on the video frames and subsequently distinguishes between fire and non-fire objects based on a set of five extracted features including color probability, spatial variation, temporal variation (flickering), spatiotemporal variance and contour variability of candidate blob regions. Classification is based either on classifiers trained with fire and non-fire video frames or on a rule-based approach.

Finally, SUPCOM developed a real-time flame detection system for video sequences captured by both fixed and moving (PTZ) cameras. First, moving objects are detected in each frame. Then, a set of flame characteristics including color, temporal intensity variance, spatial intensity variance, shape variation and shape complexity are extracted and classified as flame or non-flame using a set of fuzzy Context Independent Variable Behaviour (CIVB) classifiers.

Computer vision based smoke detection

Smoke observed from a long distance and smoke observed from up close have different spatial and temporal characteristics. Wildfire smoke appears to move very slowly after a couple of hundred meters and it does not exhibit turbulent behaviour when monitored by a video camera. Based on this observation, BILKENT developed two different algorithms for close range and long range (wildfire) smoke detection.

The close range smoke detection algorithm first detects regions with smoke-like color (grey/white) to decrease the search area in the frame. Then, the video is divided into spatiotemporal blocks and a set of covariance descriptors is extracted for blocks with smoke-like color. The long-range smoke detection algorithm consists of three main sub-algorithms: (i) slow moving object detection, (ii) smoke-colored region detection, and (iii) correlation based classification. Both algorithms obtain high detection rates while exhibiting increased robustness to false positives due to the presense of clouds, fog or moving objects.

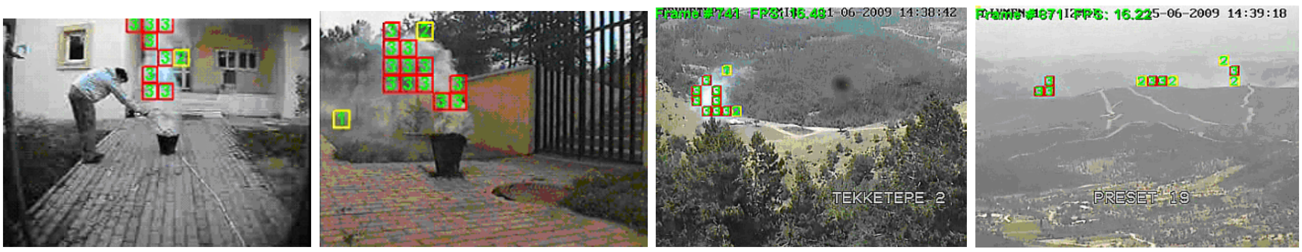

Figure 6: Smoke detection results using BILKENT's algorithms for close range (first two images) and long range (last two images) fires.

BILKENT also developed an Entropy functional based Online Adaptive Decision Fusion (EADF) framework for image analysis and computer vision applications and improved former smoke detection results. In this framework, sub-algorithms of the smoke detection module are combined with weights, which are adjusted online according to the changing light and environmental conditions. In this way, it is possible to fuse the results of several smoke detection algorithms analyzing the scene in parallel. Improved performance was achieved for wildfire smoke detection at an early stage.

Finally, SUPCOM investigated the possibility to embed an early smoke detector into the camera in order to send a quick alert to the monitoring center immediately after video acquisition. Generally, the two video compression standards MJPEG and MPEG2 are commonly available in most cameras. They both involve a blockwise Discrete Cosine Transform (DCT). SUPCOM's first contribution for designing such smart camera functionality consists of exploiting the local fractal feature of smoke areas based on the DCT coefficients. The second novelty relies in refining the estimation of the fractal feature by considering larger blocks of coefficients to increase detection accuracy without increasing the complexity. This technique could be very useful in low bit-rate transmission applications.

Figure 7: Smoke detection results using the EADF framework in wildfire video sequences.

IR camera based fire detection

Three prototype multispectral cameras were developed by XENICS. Meerkat Fusion consists of three cameras at different wavebands: visible, SWIR and LWIR. Meerkat PTZ consists of two cameras at visible and LWIR spectrums. Finally, Meerkat Fix consists of a LWIR and a SWIR camera. The cameras are capable of recording videos simultaneously and transmit the videos to a computer through Ethernet.

Figure 8: Meerkat Fusion, Meerkat PTZ and Meerkat Fix cameras developed by XENICS.

Figure 9: Images from field tests performed in Antalya, Turkey in May 2011 using the Meerkat Fusion multispectral camera: a) visible image, b) SWIR image and c) LWIR image of the same scene.

XENICS made an in-depth analysis for infrared data processing. Each aspect of the infrared radiation was studied: (i) physical aspect (physical infrared radiation modelling and effect of environment), (ii) electro-optical system aspect (infrared radiation detection, including image contrast and background noise influenced by lenses, camera resolution and other sensor characteristics) and (iii) image processing aspect (infrared data analysis).

Three approaches were implemented by XENICS for automatic infrared fire detection: the first two approaches are designed for long range fire detection based on SWIR and LWIR cameras. The image processing is performed separately in each waveband and the fusion is performed at the decision level. These two methods take advantage of the high dynamic of these cameras. The third approach is designed for short range fire detection based on both LWIR and visible cameras. The multi-sensor flame detection algorithm first searches for candidate flame objects in both LWIR and visual images based on moving object detection and flame feature analysis. Next, the registration information is used to map the LWIR and visual candidate flame objects on each other. An alarm is issued if the flame probability of the mapped objects is high.

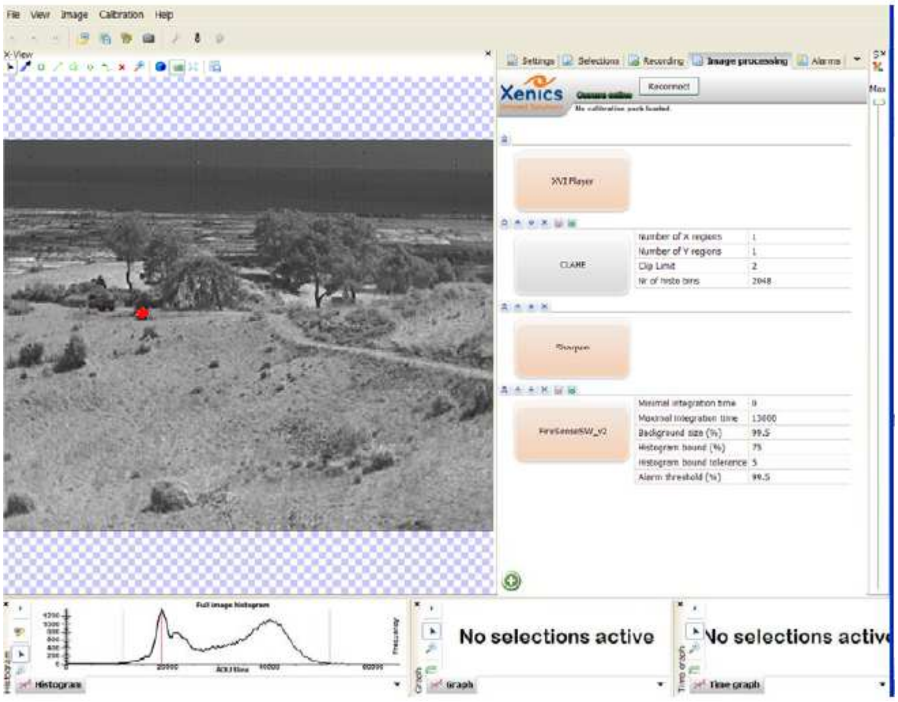

Figure 10: Detection of fire in a sequence recorded by a SWIR camera. Two fires with size 1m^2 and 2m^2 respectively are detected. The screenshot is from the IR software platform developed by XENICS.

Other methods were also investigated such as the detection of the potassium lines or the Time of Flight flame detector. The first method is better fitted for airborne fire detection because the forest could occlude the potassium emission. The potassium lines are seen at the start of the fire because the potassium is released at the beginning of the fire when the temperature is high. These potassium emission lines could be occluded by the dark smoke. The Time of Flight flame detector is best fitted for short-range fire detection.

BILKENT also developed an IR-based flame and smoke detection algorithm. The algorithm starts with segmenting moving hot objects. Then several features including boundary box disorder, histogram roughness, principal orientation disorder, center mass disorder, etc. are extracted from the segmented regions and are used to decide whether the hot moving objects represent fire or not..

PIR sensor based fire detection

A flame detection algorithm using pyro-electric infrared or passive (PIR) sensors was developed by BILKENT. Two versions of this algorithm where implemented. The first can run on a PC. The second is implemented as a standalone system using digital signal microprocessors. A differential PIR sensor is only sensitive to sudden temperature variations within its viewing range and it produces a time-varying signal. This signal is analyzed using Markov models corresponding to the flame flicker process of an uncontrolled fire, ordinary activity of human beings and other objects.

Comparative results show that the system can be used for fire detection in large rooms. Conventional point smoke and fire detectors typically detect the presence of certain particles generated by smoke and fire by ionization or photometry. An important weakness of point detectors is that the smoke has to reach the sensor. This may take significant amount of time to issue an alarm and therefore it is not possible to use them in open spaces or large rooms. The main advantage of the differential PIR based sensor system over the conventional smoke detectors is the ability to monitor large rooms and spaces because it analyzes the infrared light reflected from hot objects or fire flames to reach a decision. The PIR system shows very high detection rate and low false alarm rate. A flood detector, which works by sensing if water is present at its contacts, was also integrated in this board. This standalone system presents an ideal low-cost solution for fire and flood detection in large rooms.

Figure 11: Standalone PIR system. A flood detection sensor is also integrated in the board (the PIR sensor is the white box; the flood sensor is the one with the white cable)

Software platforms for fire/smoke detection

The video-based smoke and flame detection algorithms developed within WP3 have been integrated in two software platforms: a standalone software platform used for algorithm testing using pre-recorded videos and an online software platform that can be connected with a range of different cameras and can detect fire in real-time. The on-line platform can support many cameras at the same time (PTZ cameras also) and provides a user friendly interface that allows the display of live streams from the cameras, issue of visual and audio alarms at real time, addition of new cameras, adjustment of camera parameters, selection of flame/smoke detection algorithm to use, display of camera positions in Google Earth, etc. The online smoke and flame detection platform developed by BILKENT has been installed in many watch towers in Turkey in cooperation with the Turkish General Directorate of Forestry. A software platform for the detection of fire in pre-recorded IR sequences was also developed by XENICS.

Weather data collection

Weather measurements are collected from local weather stations installed at the test sites. Polling of real time weather and forecast data from public weather sites and national meteorological agencies is also supported. Commercial weather stations were installed in most pilot sites, while in Kabeirion a prototype weather station, especially designed for FIRESENSE, was employed.

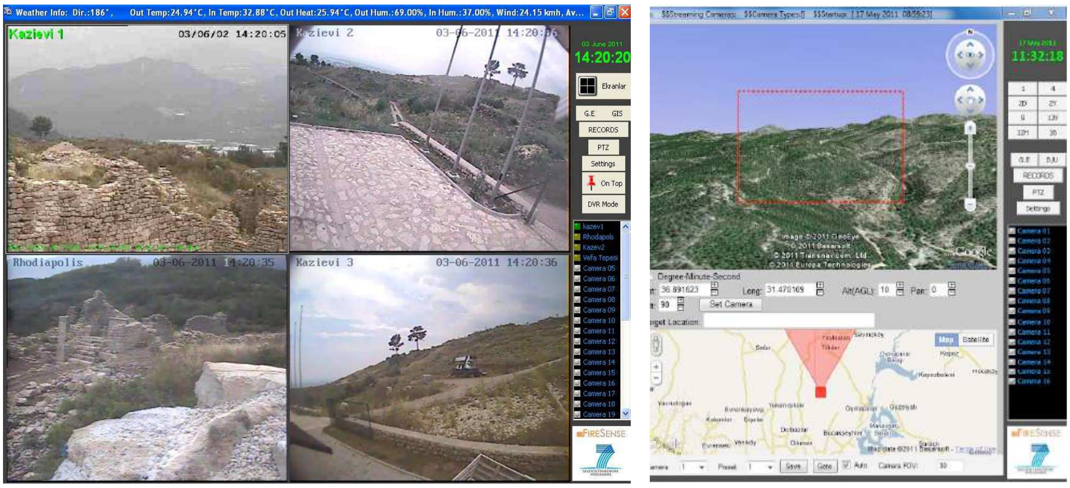

Figure 12: Online fire/smoke detection software platform.

WP4: Wireless Sensor Network

The main results of the research performed within WP4 is the development of a novel wireless sensor network (WSN) for monitoring environmental parameters, which coupled with a wireless data network (WDN) for video surveillance can be used for the detection of fire.

Wireless Sensor Network

A novel wireless sensor network was designed and developed by CERTH. The design approach primarily targeted at a robust solution for outdoor deployment that can operate on cheap-to-replace batteries for a long period, while maintaining a good response to sensing a wildfire. Moreover, given that the WSN is part of a critical system to which responsible personnel relies for early warnings, any WSN subsystem malfunction should be reported immediately and effectively along with its location. For that reason, a clustered network hierarchy is designed with clusters of approximately 10 sensors governed by a dual-radio clusterhead device with more resources than the sensor platform. Clusterheads uses low range, ultra-low power radio to communicate with sensors that can be placed around them at a distance of 80 meters at most. The clusterheads themselves are collecting local sensor measurements and send them via long range WiFi (upto 200 m) to a WSN aggregation point. In addition, the clusterheads are passively monitoring local sensors and their behavior and report problems immediately. Within FIRESENSE, the clusterheads implemented advanced sleep scheduling and multi aggregation point selection algorithms, which increase robustness and fault tolerance.

The WiFi network formed by the clusterheads is an ad-hoc network that introduces full deployment flexibility since a clusterhead can be placed beyond the 200 m barrier from the aggregator point and use neighbour clusterheads that are closer for measurement propagation in a multi-hop manner.

A considerable amount of effort was invested in integrating the WSN in a controllable and effective way with the Data Fusion module. For that reason, an HTTP-based REST API with human readable XML responses was used to drive the WSN. The API recovers from malfunctions during request processing like network loss or device failure and returns appropriate messages for all error conditions, so that the data fusion can handle them. The integration with data fusion included a long testing period and the behavior of the WSN has been selected to bridge the Data Fusion response demands with the low power requirements. As a result, the Data Fusion engine can effectively interpret temperature and humidity readings to discriminate between fire and direct sun light exposure, which is one of the main problems in WSN-based fire detection.

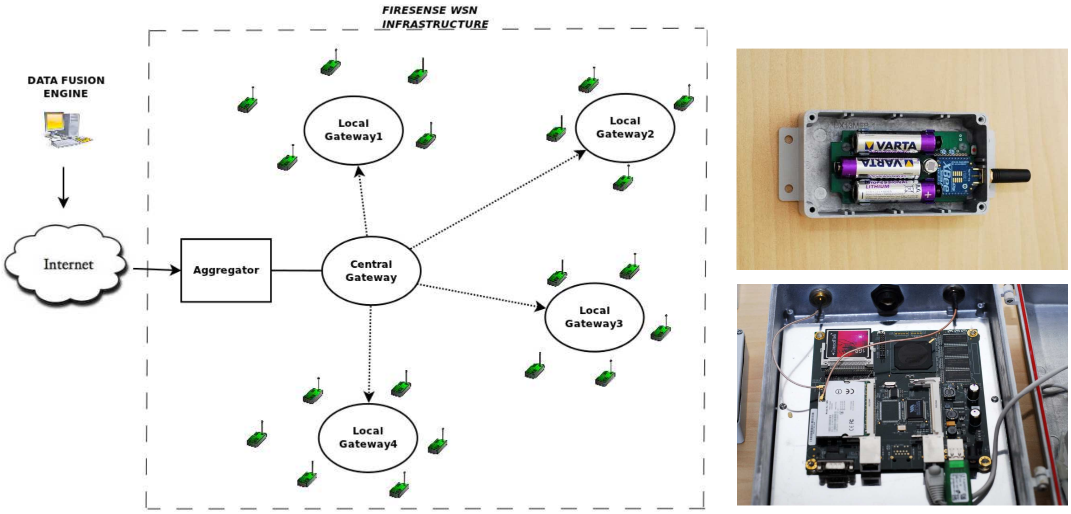

Figure 13: WSN cluster based architecture (left), sensor node (top) and clusterhead (bottom).

WSN security has been thoroughly considered and several security extensions have been implemented to both the WiFi adhoc network and to the authentication of REST API messages to avoid man-in-the-middle attacks that wish to deceive the control centre. The WSN has been thoroughly tested and has been deployed in Kabeirion, Rhodiapolis and Dodge Hall test sites.

WSN routing and scheduling

To efficiently utilize WSN energy and to effectively and reliably carry the sensed data to the control center, new WSN routing and activity scheduling protocols were designed and implemented as well. First, efficient routing algorithms and MAC algorithms have been surveyed and two suitable routing protocols and a MAC protocol have been developed by BOGAZICI. Routing algorithms must address the problem of congestion, which is a major source of data loss in wireless sensor networks adversely affecting the reliable data delivery and consequently the success of the fire detection and monitoring applications. Fire detection is an event-triggered application and given the dense deployment of the sensor nodes, many of the sensor nodes detect the same fire event and create a burst of emergency data destined to the sink, which creates transient local congestions in the network. To address these issues, BOGAZICI has developed a Load Balanced Reliable Forwarding (LBRF) algorithm and modified it to its cross-layer geographic forwarding scheme, which aims to increase the reliable data delivery in wireless sensor networks by avoiding congestion using a distributed and a dynamic load balancing approach.

Deployment of multiple sinks (multiple aggregation points) is another solution for the congestion problem in sensor networks, which also provides extra benefits in terms of energy-efficiency and reliability. A multi-sink sensor network is also more robust against the inaccessibility of a sink node due to single point of failures such as node failures (energy exhaustion), node destructions (fire) or communication destructions (fire). Hence, BOGAZICI also developed a routing algorithm for multi-sink sensor networks for fire detection. The proposed algorithm is implemented in the clusterhead platform developed by CERTH. The algorithm has been equipped with a fuzzy decision mechanism for choosing the aggregation point (sink) to be used for each event report. In the case of fire, the target sink may be blocked or destroyed. Multisink routing will allow the WSN to report the emergency events and the temperature readings even while some of the sinks are unreachable.

Considering that the fire risk can be low during some periods of time, or deployment could be dense, not all sensor nodes need to be active all the time. Some of them can be put into sleep mode for a while. By appropriate sleep scheduling (which is also referred to as node activity scheduling or duty cycling), energy consumption can be reduced in wireless sensor networks, especially when the deployment is quite dense, which is the case expected in wireless sensor networks used for fire detection and management. BILKENT has proposed a distributed and energy efficient sleep scheduling and routing scheme that can be used to extend the lifetime of a sensor network while maintaining a user defined coverage and connectivity. The scheme can activate and deactivate the three basic units of a sensor node (sensing, processing, and communication units) independently. A simplified version of this scheduling scheme was specified and incorporated into the sensor network platform developed by CERTH.

Additionally, robust cooperative networking approaches (CWSNs) were developed by SUPCOM to reliably and efficiently carry sensory data over multiple hops and groups of nodes to the center. The main idea consists of selecting, sequentially, a group of relay nodes at each hop, called cooperative nodes. For a group of cooperative nodes, a cost function is attributed to each node. Depending on the value that a cooperative node has compared to its neighbors, it is decided whether it is the best node among its group members to forward the current data packet. The decision depends on the policy chosen for attributing cost values. Two policies were studied by SUPCOM: the first focuses on distances between nodes; the second focuses on link reliability between forwarding nodes (RSSI) and the residual battery energy of cooperative nodes. The cooperative communication approach enhances the network lifetime by reducing the average packet delay and the number of retransmissions.

Wireless Data Network

To carry video and sensory data, a long range wireless data network (WDN) is designed as well. Several different technologies (GSM/GPRS/3G, WiMAX and WiFi) have been investigated and the decision converged to use a WiFi based solution. Point-to-point and point-to-multipoint WiFi links with directional antennas and longer range transmission capabilities are selected and used in pilot sites. Based on the needs and unique characteristics of each site, different WiFi based WDN networks were designed, integrated and installed in each site.

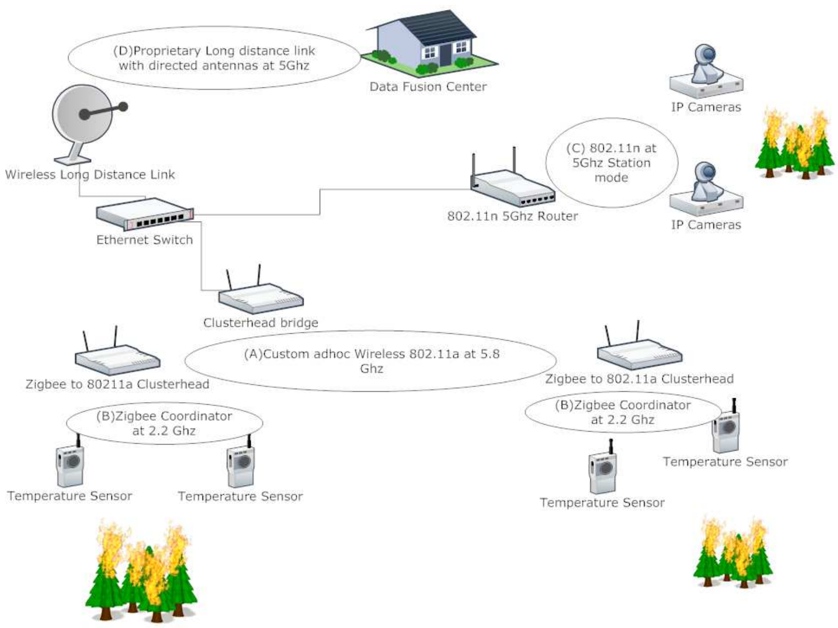

Figure 14: WDN and WSN set up in Kabeirion, Thebes.

Testing and evaluation of the network

Extensive laboratory and field tests with real experimental fires were performed to evaluate the effectiveness and performance of the WSN and the WDN. Additionally, installations and tests were performed in FIRESENSE pilot sites as well. The experiments were also helpful to tune the performance parameters and update the WSN-based fire detection algorithms. Experimental results show that the developed WSN is capable of robustly carrying temperature and humidity values to the data fusion engine and successfully triggering alarms in case of fire.

WP5: Multi-Sensor Data Fusion and Estimation of Fire Propagation

The main S&T results of WP5 include: a) new algorithms for multi-sensor data fusion, b) new algorithms for vegetation classification based on satellite images, c) ground surveys for the estimation of fuel models, d) development of a Google Earth based application for the estimation and visualization of fire propagation and e) development of the FIRESENSE control centre for the monitoring of culture heritage areas for the risk of fire and extreme weather conditions.

Multi-sensor data fusion

Several techniques for fusing data from different sensors have been examined within Firesense aiming at increasing fire detection rates and reducing the number of false positives.

First, the concept of image fusion at the pixel level was investigated. To this end, CWI focused on fusion of images obtained from visible and IR (i.e. SWIR and LWIR) cameras. One fundamental problem in this respect is that these images need to be co-registered, a task which is complicated by the fact that image properties and characteristics of corresponding points might be quite different, especially when one compares visible or near IR images with images for long wave IR (thermal information). In particular, there are many instances where the statistics of image patches around points of interest are unrelated and therefore difficult to compare (e.g. due to opposite contrast). A feature-based registration algorithm was designed, which uses lines derived from edge pixels (instead of points of interest as the majority of existing algorithms) as edge-correspondences are easier to identify. Experimental results show that this technique outperforms other existing algorithms when registering images captured by an infrared camera and a visual camera.

In the second strand of this research, CWI investigated fusion schemes that can handle the above-mentioned opposite contrast. This is something that occurs quite frequently when a scene is observed in both the visible and MWIR or LWIR spectrum (i.e. predominantly thermal information). Bright patches in visible light might actually be cooler than their surroundings and therefore darker in the IR images. CWI developed an approach in which the fusion rule selects one of the modalities as base image and uses a saliency rule to decide whether or not contrast contributions from the other modalities need to be inverted. A software tool for image registration and fusion providing a graphical user interface has been developed to this end.

CWI concluded its work on image fusion by implementing a saliency-aware multi-modal fusion algorithm in which the wavelet-based fusion is biased to assign a greater prominence to the thermal image wherever in thermal saliency is detected. The result therefore shows an image which strongly resembles the visual input image and is therefore more easily interpreted by a human operator, but at the same time highlights any thermally salient region (e.g. fire) that might be present.

Image fusion at the pixel level requires accurate image registration, which is difficult when the cameras are pointed at natural scenes in which few rigid and fixed keypoints are visible. For that reason, ways of combining the decision information obtained from visible and thermal cameras were also investigated. More specifically, by defining thermal saliency in terms of motion and (thermal) brightness it becomes possible to combine the bounding boxes for flame detection that are obtained in both the thermal and visible images in order to reduce the number of false positives without decreasing the sensitivity of the system. In a related development, CWI has collaborated with partner XENICS to implement a data-driven thresholding algorithm that takes advantage of IR-sensor integration time optimization. The underlying idea is that a judicious choice of the IR sensor integration time allows one to optimize the contrast between hotspots due to fire and the cooler background. It then becomes easier to detect the onset of fire.

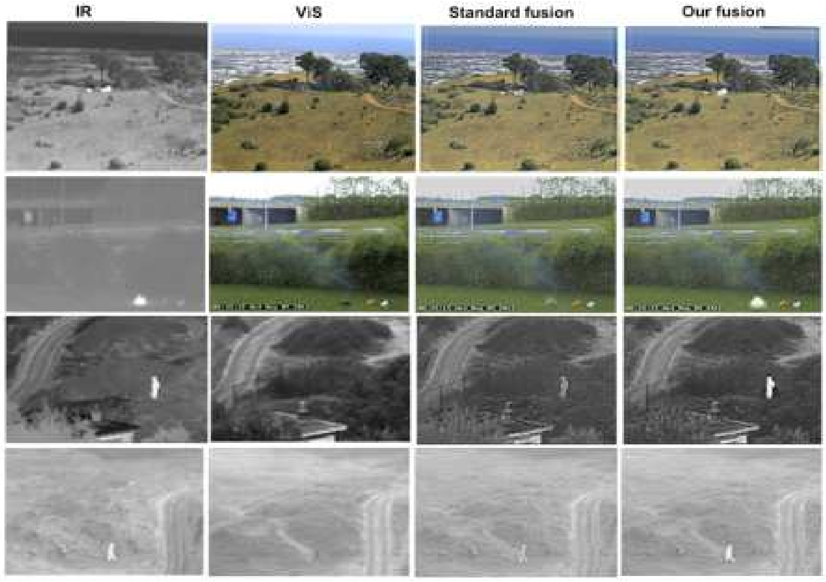

Figure 15: Image fusion example. The last column shows the result of the saliency-aware, multi-modal fusion algorithm.

CWI also developed a data-driven event-detection algorithm for the data streams emanating from temperature nodes in wireless sensor networks, and tested it for the WSN architecture developed by CERTH. In addition, CWI implemented algorithms for fire risk index computation and extreme weather warnings, based on sudden changes in temperature, barometric pressure and wind speed/direction as measured by the meteorological sensors.

Most of the aforementioned data fusion algorithms are integrated in the data fusion software module, which plays a central role in the generation of alarms and the communication between the cameras, sensors and control centre.

Vegetation classification and fuel modelling

A fuel model is a preliminary representation of vegetation characteristics used in analyzing fire behaviour. One of the objectives of the research performed within FIRESENSE was to propose new techniques to improve the vegetation and fuel model description of the selected pilot sites.

Towards this aim, several algorithms for vegetation classification have been developed by SUPCOM and CNR based on satellite images. Commercial satellite images have reached a fairly high spatial resolution, which allows more powerful textural analysis and more detailed description of soil surface. This improves the capacity to recognize and classify land uses, the amount and typology of vegetation and other potential sources of fuel for wildfires. It also reduces substantially the time and costs for updating vegetation and fuel distribution.

A two-step approach for vegetation classification was proposed by SUPCOM, which applies multi-band supervised SVM (Support Vector Machine) classification followed by temporal analysis. In the first stage, spatial, spectral and textural features characterizing vegetation are extracted from the original data and are combined with the spectral information through the SVM algorithm. The spectral information is introduced through the normalized difference vegetation index (NDVI), the texture features are extracted using Gabor wavelet decomposition and the spatial interaction within each channel is considered by taking into account the ground spectral responses according to the different spectral bands. In the second stage, the temporal behaviour of the land cover is analysed.

The type, location and time of the vegetation changes are tracked and the parameters of the fire propagation model are updated accordingly. This spatio-temporal classification approach based on the combination of several features was applied to satellite images of the pilot sites: Galceti Park, Temple of Water, Kabeirion and Rhodiapolis. The results give a good discrimination between classes for all sites, especially for Kabeirion where the vegetation areas are well delimited. The generated vegetation maps were geo-referenced to allow their use by the EFP module. To produce the fuel map for fire propagation estimation, the CORINE nomenclature was used.

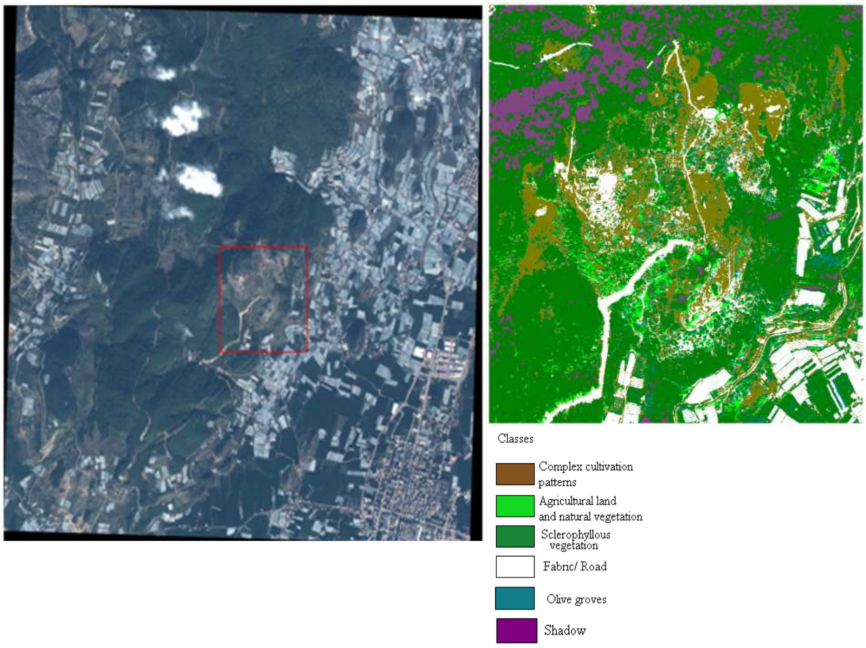

Figure 16: Vegetation classification result for Rhodiapolis (right) based on the Worldview-2 image of the area enclosed by the red rectangle (left).

CNR also developed a vegetation classification algorithm, which works as follows: first, a pixel-based preliminary classifier is used which explores all available spectral information from multi-temporal satellite images and maps each pixel into a discrete and finite set of labels that identify land-cover-class sets: a) vegetation; b) either bare soil or built-up; c) either water or shadow; d) snow or ice; e) clouds. The second stage includes stratified class-specific context-sensitive feature extraction. In this context, vegetation can be subdivided into evergreen forest, deciduous forest, woody cultivated areas (e.g. olive groves, orchards), grassland and shrub.

CNR evaluated a procedure for estimating the biomass/fuel based on allometric relationships. Allometric models represent a non-destructive and time-efficient alternative for determining biomass indirectly and are based on correlations between biomass and easy-to-measure vegetation parameters, such as basal diameter, shrub height, or vegetation cover. A fuel model was developed in order to obtain a spatial distribution of fine and coarse fuel through remote sensing (Very High Resolution satellite images were used). The model was based on empirical relationships (regression analysis) formulated between the biomass and NDVI. Once the regression parameters were determined, an estimate for the biomass at any pixel in the image (provided vegetation is growing here) could be computed.

Creation of fuel maps can also be carried out by site survey by experienced forestry researchers. In Kabeirion, such a survey was conducted by Dr. Gavriil Xanthopoulos, an expert in fuel modelling and researcher at the Institute of Mediterranean Forest Ecosystems and Forest Products Technology of the National Agricultural Research Foundation of Greece, who was awarded a subcontract by CERTH. This work involved a detailed comparison of satellite images and vegetation at on-site sampling points, judiciously selected to provide accurate and detailed ground truth on fuel-related parameters. The survey has resulted in the identification of 13 existing fuel models (no custom models were used). This made it possible to manually define a ground truth fuel map for a small area around the archaeological site of Kabeirion. This information was then utilized by SUPCOM to producing a more accurate map of the vegetation cover in this area.

A second survey concerned the use of physical and/or hybrid models for the estimation of the probability of fire ignition and spread in the same test site. A subcontract was assigned to OMIKRON LtD (which also participated in the FP7 FireParadox project), which conducted a study for modelling a large rectangular area of approximately 12kmx6km around Kabeirion. The main motivation was to integrate a physical model-based fire spread technique into the EFP (estimation of fire propagation) application in order to be able to compare the results of such models with those provide by the semi-empirical BEHAVE-based models used in the EFP.

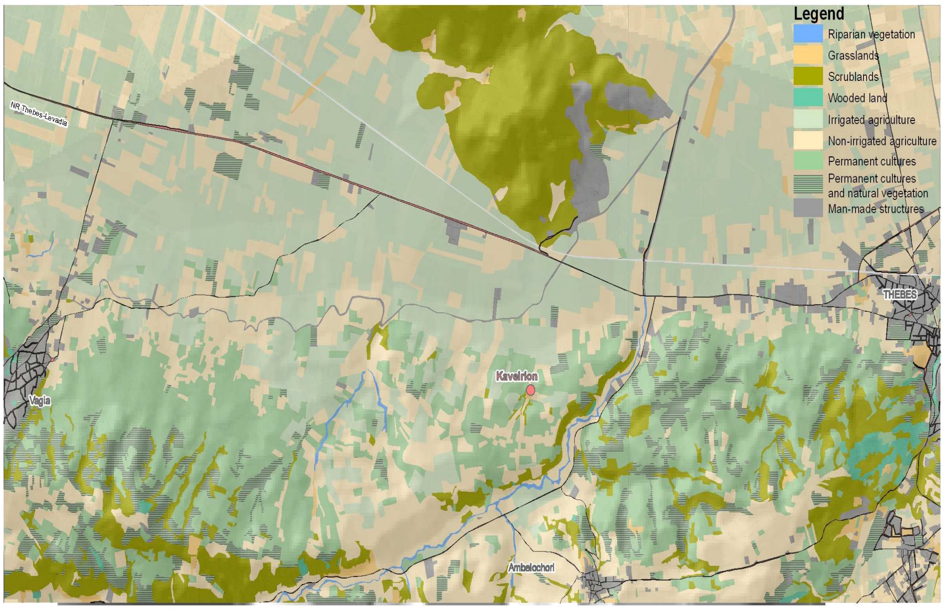

Figure 17: Vegetation and land cover types in an area 12km x 6km around Kabeirion.

Estimation and visualization of fire propagation

Visualization of fire propagation data is important since it enables early intervention of the fire and helps the fire management teams to deploy their forces wisely. To this end, an interactive software application, which provides parameterized simulations of the fire propagation and visualizes the estimated results on a Google-Earth based environment, was developed by CERTH. Fire spread calculations are based on the popular BEHAVE algorithm, while physical models simulations are also supported via the open source VESTA software.

According to the BEHAVE model, fire propagation depends on a number of parameters such as the terrain topology around the ignition points, weather conditions such as wind and moisture, as well as fuel information. The latter factor summarizes vegetation characteristics that have a major impact on fire propagation. These parameters are either provided by the user or are automatically estimated based on available data. Specifically,

- Wind information is obtained in real time from existing weather stations or from internet weather portals.

- Digital Terrain Models (DTMs) are obtained by STRM data (90m resolution) that are freely available for the whole world.
- Fuel moisture information can either be manually provided by the user, directly measured using special sensors or estimated from weather data (i.e. temperature, humidity, etc).
- Fuel information is provided either by CORINE land cover maps, which are converted to fuel maps (containing indices to BEHAVE or custom fuel models) or directly as fuel maps.
- Ignition points can be provided manually or obtained by the Control Centre (the Control Centre provides an estimation of the fire ignition point based on the outputs of the fire/smoke detection module and the data fusion module).

The estimated fire propagation is visualized on a user-friendly 3D environment based on Google Earth. Google Earth was chosen because it is publicly available and widely used by experts and non-experts alike. Besides static views, it also allows the creation of impressive 3D animations of the fire propagation. Google Earth also provides standard access to useful layers that create functionalities and added value for the user such as real time weather information, street view, borders and labels, and Panoramio photos. Additionally, there are layers for important information about the monitored site such as the location of sensors and cameras, vegetation maps and regions of interest. Influential environmental parameters such as the fire ignition point or humidity values can be set interactively, and weather data are automatically acquired, e.g. from onsite or nearby weather stations.

The EFP application produces 2D or 3D visualizations of the fire propagation estimation output: ignition times are displayed as colour coded grids, while flame length animations in KML format are also generated. Support for adaptive resolutions in fire propagation estimation has been implemented, allowing the simulation to run faster, while still attaining the same resolution and performance within the regions of interest. Real-time data from the WSN sensors can be exploited within the EFP simulations by modifying the associated fuel map. In addition, the software offers support for improved spatially varying wind fields using the WINDNINJA client interface. Moreover, moisture estimates can be obtained either from weather parameters using Nelson's dead moisture model or from specialized sensors (e.g. the 10-h sensor). A model for predicting the probability of transition of a surface fire to a crown fire of the vegetation was also implemented.

Finally, CERTH in cooperation with OMIKRON LtD integrated VESTA (open source Large Scale Fire Simulator software) with FIRESENSE EFP, so that a) a Fire Risk map can be displayed and b) simulations of fire spread using physical or hybrid models can be executed via the EFP GUI.

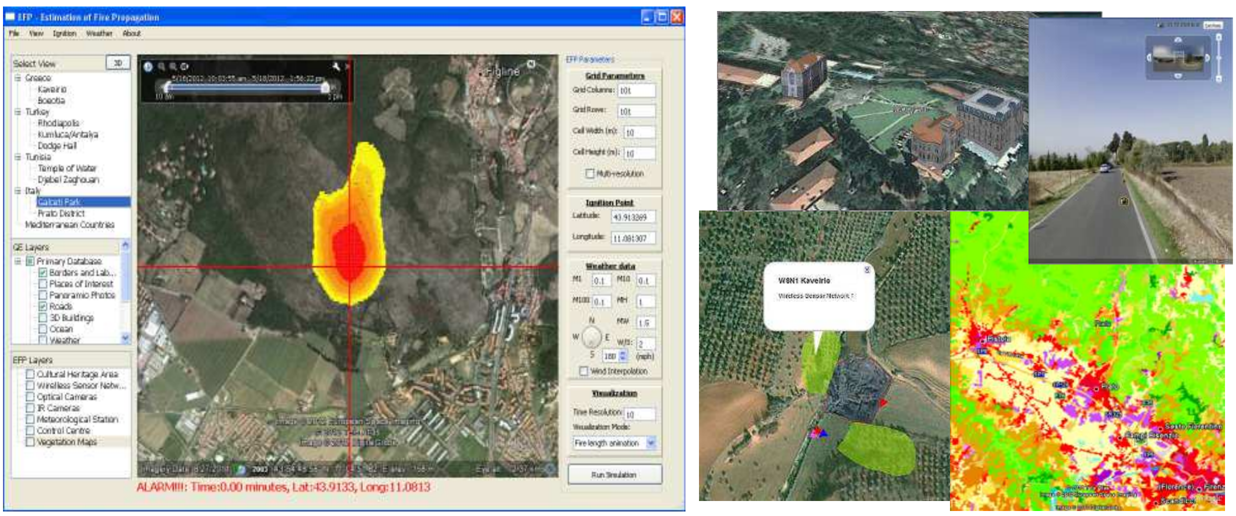

Figure 18: EFP (Estimation of Fire Propagation) software platform GUI

FIRESENSE Control Centre

SUPCOM designed and implemented the FIRESENSE Control Centre (CC) and its related Graphical User Interface (GUI). The architecture of the CC application and its connections to the other modules is outlined in Figure 19. The Control Centre allows:

- display of layered maps of the monitored site;
- monitoring of the site through different sensors and cameras;
- collection and visualization of measurements from the sensors and videos from the cameras;
- configuration of sensors and manipulation of cameras;
- display of sensor statistics;
- generation of different types and levels of alarms when a situation is judged as suspect or dangerous by the data fusion module.

For efficient visualisation, the GUI comprises of three graphical interfaces: the main screen, the video screen and the maintenance screen. The main screen shows the map of the supervised area and the location of installed equipment (WSN sensor, cameras, PIR sensors, weather stations, communication links are presented as icons) and displays the alarms. The user can click on a WSN sensor icon to get information about its status, incoming data flow and parameters that are reconfigurable. In the same way, clicking on a camera icon allows the display of a small window showing the video acquired by this camera in real time.

The alarms generated by the Data Fusion module are displayed on the Main Screen as shown in Figure 20: a visual and sound alarm is displayed on the top along with a text box indicating the alarm type (e.g. smoke). A bounding box and a flag indicating the alarm location (defined by the GPS coordinates of the ignition point) is also shown on the Google map. The main screen also allows the user to trigger the EFP application, which visualizes the estimated fire propagation.

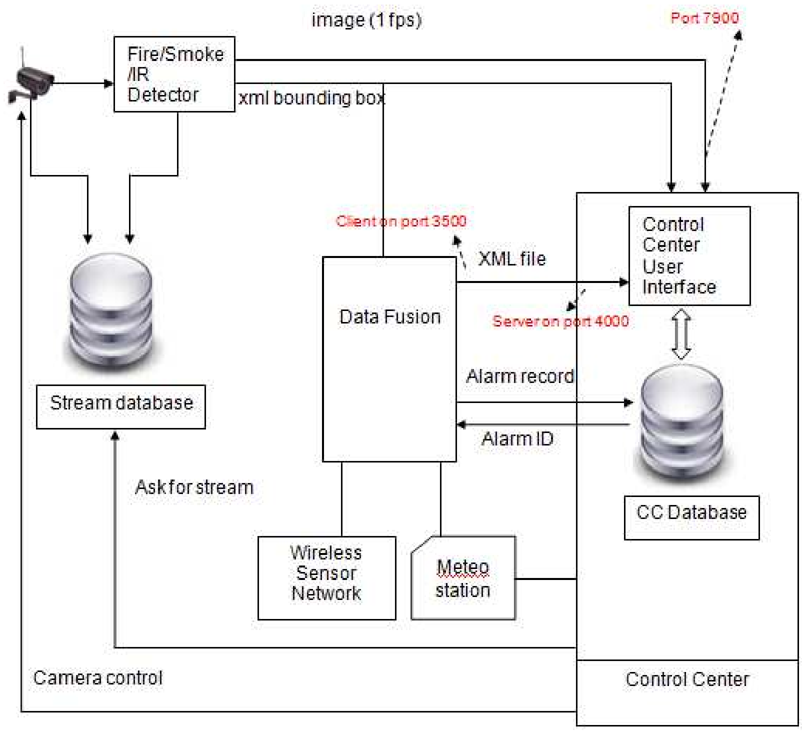

Figure 19: Communication pattern between the Control Centre server, detectors (i.e. cameras, WSN and meteorological stations) and Data Fusion module.

Figure 20: Visualization of smoke detection alarm in the main screen of the Control Centre.

The video screen is dedicated to the cameras and their manipulation. This interface is composed of two sub-windows. The biggest one is dedicated to the display of the video stream of a given camera selected by the user. The second sub-window displays a mosaic of all the video streams from the remaining optical and IR cameras. Furthermore, the user can adjust camera parameters (e.g. pan-tilt-zoom of PTZ cameras). In case of a fire alarm, the cameras can automatically turn to monitor the area surrounding the estimated ignition point on user demand. Finally, on user demand, the video screen offers the possibility to display the result of fusion of visible and infrared images acquired by the optical and IR cameras connected to the CC based on the image fusion algorithm described above.

The maintenance screen allows controlling the status of the sensors/cameras/communication links. For each sensor, its energy consumption can be displayed, while an alert is issued in case of dysfunction or breakdown (e.g. vandalism or battery out of order).

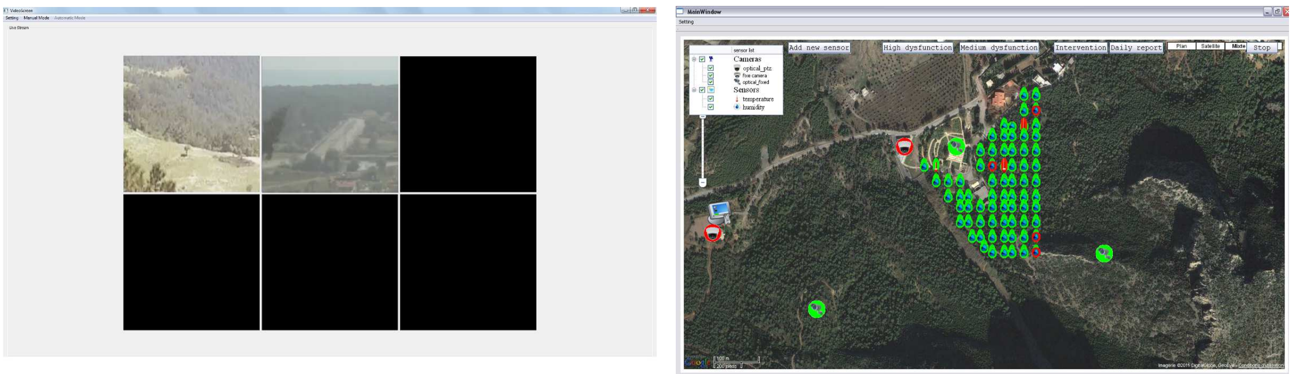

Figure 21: The video (left) and maintenance (right) screens of the Control Centre.

WP6: System Integration and Demonstration

In the context of WP6, the FIRESENSE system was installed and demonstrated in five cultural heritage sites: Kabeirion (Thebes, Greece), Rhodiapolis (Antalya, Turkey), Dodge Hall (Istanbul, Turkey), Temple of Water (Djebel Zaghouan, Tunisia) and Monteferrato-Galceti Park (Prato, Italy). The five pilot sites have quite different characteristics: Dodge Hall is a building; Kabeirion is an archaeological site mainly surrounded by cropland, where one of the major fire risks comes from burning straws and crop residues; the archaeological site of Rhodiapolis is surrounded by greenhouses and, closer to the ruins, by poor vegetation of brushes and pine trees; the Temple of

Water is surrounded by a relatively dense forest and by some cropland; Galceti is at the border between a pine wood, some cropland and town outskirts. The local orographic situation is also quite different among sites, with Galceti and the Temple of Water exemplifying relatively steep, uneven landscape and Kabeirion situated in a relatively flat area.

System installation at pilot sites

The first prototype was installed in the archaeological site of Kabeirion, 8km west of Thebes, Greece. The sanctuary of Kabeirion was dedicated to gods Kabeiros, Demeter and Pais. It is located at an area which was isolated at ancient times deep in the quiet countryside as the rituals that were performed there had to be kept secret and only the initiated could attend the ceremonies. The sanctuary complex consists of the temple, the shrine, a theatre, a gallery and other buildings. It covers approximately 7,000 square meters. Nowadays the remains are surrounded by olive trees, pine trees and cereal cultivation.

The system installed in Kabeirion includes the following components: 2 PTZ cameras and 1 SWIR camera installed inside the archaeological site, a Wireless Sensor Network comprising of 50 sensor nodes (including temperature and humidity sensors) and 5 clusterheads, a prototype weather station installed at the museum of Thebes and the control centre PC installed also at the museum. A wireless IP network link with a reflection point has been deployed to connect the archaeological site with the museum of Thebes.

Figure 22: Optical PTZ camera, IR camera and WSN nodes installed in Kabeirion.

The second prototype was installed in the ancient city of Rhodiapolis in Antalya, Turkey. The most important remains of the city include the theatre, bathhouse, agora/stoa, sebasteion, temples, church, cisterns, cenotaph, necropolises and houses. The site is surrounded by forestall areas. An excavation house used by archaeologists during the excavation period is located near the site.

The system installed in Rhodiapolis includes the following components: 4 PTZ and two fixed optical cameras, a multispectral image sensing platform (including visible, SWIR and LWIR cameras), a WSN comprising of approximately 20 sensor nodes (including temperature and humidity sensors), a commercial weather station and the control centre PC, which is installed at the excavation house.

Figure 23: Cameras, WSN node and weather station installed in Rhodiapolis

The third prototype was installed in Dodge Hall in Istanbul, Turkey. Dodge Hall is located on a wooded hill overlooking the Bosporus, in the campus of Bogazici University. It is listed as a second degree heritage building by the Turkish Ministry of Culture. Dodge Hall has a large interior space similar to most buildings in Istanbul (e.g. Agia Sophia, Blue Mosque). It is demonstrative of building type monuments and has to be protected from both external and internal fires. It is an actively used indoor historical site for sport activities, physical education courses and university administration activities.

The system installed in Dodge Hall includes the following components: 2 optical cameras - one installed inside the Hall and the other monitoring the building from the outside, a WSN comprising of 5 sensor nodes (including temperature and humidity sensors) and a gateway, a PIR sensor, 3 commercial smoke sensors and the control centre PC.

Figure 24: Installation of camera in Dodge Hall and screenshot from internal camera view

The fourth prototype is installed in the Temple of Water in Tunisia, which is encompassed by the national park of Djebel Zaghouan. This temple marks the site of an aqueduct and a canal network built in the 2nd century BC under the Roman Emperor Hadrian, which used to carry water from the city of Zaghouan to the city of Carthage over 130 km away. The pilot site corresponds to an area of 3,000 ha and it is surrounded by a forest. The vegetation cover is typical Mediterranean including pine trees, mastic trees, olive trees, etc. An Eco-museum is located within the archaeological site, while the surrounding area is a leisure activities centre.

The system installed in the Temple of Water includes the following components: 2 PTZ cameras - one installed on the roof of the Eco-museum and the other on the roof of a nearby hotel, a commercial weather station and the control centre PC installed in the museum. A WiFi link connects the second camera with the museum.

Figure 25: Camera, weather station and control centre PC installed in the Temple of Water

The fifth prototype is installed in Galceti Park in Prato, Italy. Galceti Park is an open air multi-purpose site located in a Natura 2000 area, which includes a renaissance chapel, an archaeological

Mousterian site, a Natural Science museum and a small zoo. It occupies a surface of 1,760 ha mainly including pinewoods.

The system installed in Galceti includes the following components: 5 optical cameras – four installed inside the site and the fifth on the roof of a nearby school, a commercial weather station that belongs to a network of weather stations in the area of Prato and the control centre PC installed in the Natural Science Centre. WiFi links connect the cameras with the control centre.

Figure 26: a) One of the cameras installed in Galceti Park and b) screenshot from the Control Centre showing live image streams from the five cameras installed in this site.

Prior to equipment installation, special permissions were received from archaeological, cultural or other public authorities for the installation of the system in the five pilot sites. Also, significant effort was required for the preparation of test sites for system installation, which included establishment of Internet connection for open air sites, supply of power, cleaning of vegetation, repairing of existing infrastructure or old buildings, etc.

System demonstration

Several activities were organized in all pilot sites to validate system functionalities and demonstrate the system to interested parties and stakeholders.

Initially, "internal" demonstration activities without user involvement were organized, including controlled fires and artificial smoke tests to validate system functionalities, verify the correct operation of sensors and test system performance. In Galceti, artificial smoke generated by smoke candles, small and controlled fires as well as smoke from bonfires lighted by farmers in the countryside were used to test the fire/smoke detection capabilities of the system. Moreover, a set of experiments with controlled bonfires were also organized to test the IR cameras and WSN sensors. Several real fire experiments with cameras and WSN sensors have been organized in Volos and Kabeirion. Another real fire test was organized in the parking lot of Bogazici University in cooperation with the local fire department. Dry ice and boiling water were used for smoke generation in an indoor test in Dodge Hall. Two field tests with visible and IR cameras were conducted in Rhodiapolis. Several tests with small controlled fires were also organized in the Temple of Water in cooperation with local authorities. All the aforementioned tests also served for collecting sensor data (videos, signals, measurements) for system evaluation.

"Open" demonstration activities involving local users were also organized in all test sites. These events aimed at demonstrating FIRESENSE technologies to potential stakeholders, the scientific community and the general public through presentations, talks, videos and real or video demonstrations and tests of the FIRESENSE system. Interaction with the audience gave valuable feedback for system evaluation and update of user requirements.

Figure 27: Real fire test in the parking lot of Bogazici University.

Figure 28: Controlled fire experiments in Galceti Park.

In Kabeirion, an open day was organized by the IX EPCA in collaboration with CERTH. The event was attended by people from local authorities, the Ministry of Culture, the fire department, security enterprises, interested inhabitants, etc. The workshop included several presentations and videos as well as a live demonstration of the system. In Rhodiapolis, an open demonstration was organized during the FIRESENSE workshop, including a real fire simulated by the fire brigade, which was successfully detected by the system. An open demonstration for stakeholders and University staff and students was organized in Dodge Hall. The event included presentations and live system demonstration with artificial smoke generated by combination of dry ice and boiling water and artificial flame coming from a lighter. Two open demonstration events were organized in the Temple of Water: people from fire fighting departments, the Tunisian General Directorate of Forestry and the University were invited. A live demonstration of the Control Center operation was performed by setting real controlled fires using tree leaves and branches to generate smoke. In Galceti, an open day including presentations and videos was attended by local authorities and stakeholders. In all these events, system demonstration was followed by discussion and filling of questionnaires by the attendees.

Figure 29: Open days for system demonstration organized in Dodge Hall (top) and the Temple of Water (bottom).

The FIRESENSE successfully detected two real wildfires near Kumluca, Antalya. The first wildfire started on 02/09/2012 near the ancient town of Olympos (Cirali) next to Rhodiapolis and the second on 18/10/2012 near the archaeological site of Rhodiapolis.

Figure 30: Detection of real wildfires at the archaeological site of Rhodiapolis on 18/10/2012 (left) and near the ancient town of Olympos (Cirali) on 02/09/2012 (right) by FIRESENSE cameras.

WP7: Technical Assessment and Evaluation

In WP7, an assessment plan was established for evaluating the performance of the FIRESENSE system and assessing its compliance with user requirements and expectations. The assessment process was performed in two stages: first party assessment of system and system components was carried out by the partners (laboratory testing during the development phase and field testing during the demonstration phase) and second party assessment was carried out directly by system users providing feedback via questionnaires.

Laboratory testing of system modules

During system development, the main components of the FIRESENSE system (video-based smoke and fire detection, infrared based fire detection, wireless sensor network based fire detection, generation of fuel maps by vegetation classification, fire propagation estimation, and data fusion) were evaluated in laboratory conditions.

Video-based smoke and fire detection algorithms were evaluated using a test video database consisting of several sequences of fire and smoke scenes at various environments, which is available at the project website. This database includes videos downloaded from the Internet as well as numerous videos recorded during field tests and experiments organized within the project. LWIR, SWIR, MWIR and PIR recordings are also included.

Experimental results show that the developed flame detection techniques obtain high recognition rates and low false positives and are robust to problems created by sun reflections and fire-like coloured moving objects (e.g. car lights). The long range smoke detection algorithm capabilities were successfully tested using sequences of real forest wildfires. The algorithm has increased performance compared to other algorithms in the literature and can successfully discriminate between smoke and similar phenomena such as clouds or fog, which usually produce many false alarms. The PIR-based fire detector was compared against conventional smoke sensors, which it outperformed both in terms of detection accuracy and time of response.

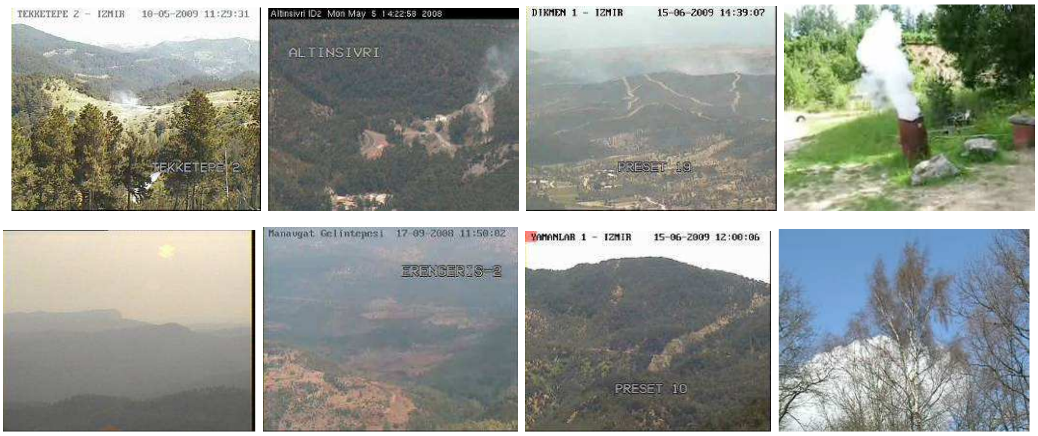

Figure 31: Fire (first row) and non-fire (second row) test videos used for the evaluation of smoke detection algorithms.

Several tests with IR cameras at different wave-bands (LWIR, MWIR and SWIR) and fires of different sizes at various distances from the camera were organized for the evaluation of IR-based fire detection techniques. False alarm generation due to the sun, sun glint and car lamps was also examined and useful conclusions were drawn for IR-based detection performance at different bands and conditions.

Several tests were also performed for assessing different components and parameters of the WSN such as temperature reading sensitivity, connectivity range between the Zigbee dongle and the sensor, battery life, worst observed delay, response to fire, etc. The proposed implementation was shown to have good performance in typical outdoor deployments and good response for fire detection.

Vegetation classification techniques were evaluated using ground truth data from site surveys and available vegetation maps. The algorithm for the estimation of fire propagation (EFP) was tested with historical data of past fires in Greece and Turkey where none or negligible human intervention occurred.

Finally, the data fusion algorithms were evaluated using data recorded during field tests with different cameras and WSN sensors. The algorithm for the registration and fusion of multimodal images (visible and IR images) was tested on pairs of IR and ViS images/videos describing indoor and outdoor scenarios. The proposed line-based registration technique showed clear advantages over the point-based registration. Observing the IR and visible sequences, only the fused image showed both the smoke and the fire clearly, deducing that the image fusion can be helpful for human visualization and inspection. Moreover, the fusion of visible and thermal data at the decision level showed that it can significantly reduce the number of false positives without reducing the sensitivity of the fire detection.

Assessment and optimization of WSN performance

The evaluation and optimization of the fire detection performance of the WSN was performed separately via OPNET simulations. To this end, BOGAZICI and CERTH investigated the event reporting capabilities of the WSN under realistic fire simulations. BOGAZICI implemented flat and Zigbee+WiFi based WSN models in OPNET and CERTH developed a realistic fire propagation estimation software module (EFP). Various temperature models that rely on heat transfer by thermal radiation were studied and integrated into the EFP software.

The integrated evaluation system works as follows: Given the fire ignition point, area morphology and fuel model and local weather conditions, the EFP module outputs the temperature changes at each sensor location at given time steps. The OPNET simulator uses this information for data generation. The sensor data generation model supports two modes of operation: normal and alert. The period for reporting temperature data is longer in the normal mode and shorter in the alert mode. Two temperature thresholds are defined: the first threshold determines when the sensors switch from normal operation mode to alert mode. The second threshold defines the temperature value over which the sensors are destroyed, affecting the routing decisions and accessibility to sinks and, hence, the fire detection performance of the WSN. Three OPNET node models were designed and implemented: Zigbee capable sensor device, Zigbee+WiFi capable hybrid local gateway device and WiFi capable central gateway device.

The OPNET models were tested in simulations driven by realistic fire scenarios produced by the EFP. The aim was to determine the effects of sensor and WSN related factors (number of deployed sensors, local gateway WiFi communication range, temperature threshold values, reporting frequency in alarm mode, etc.) on the fire detection performance of the WSN. The effect of weather and environment related factors (wind speed/direction, number/position of ignition points, fuel and moisture model, etc.) was also investigated. The metrics to be gathered from the simulations were determined as: a) freshness of temperature map, b) reporting delays, c) percentage of report losses, d) time between fire ignition and first alarm report received. Simulation results indicate that the freshness of the temperature map and the percentage of report losses is greatly affected by the alarm mode reporting frequency (higher reporting frequencies leading to more fresh temperature maps while increasing the report losses).; The reporting delays are influenced mostly by the local gateway WiFi communication range (longer ranges resulting in less delays). The time between the fire ignition and the first alarm report is affected by the number of sensors deployed (higher number of sensors deployed in the same area results in faster fire detection). These results provide an insight towards the optimization of the tunable WSN parameters to achieve the best fire detection and monitoring performance.

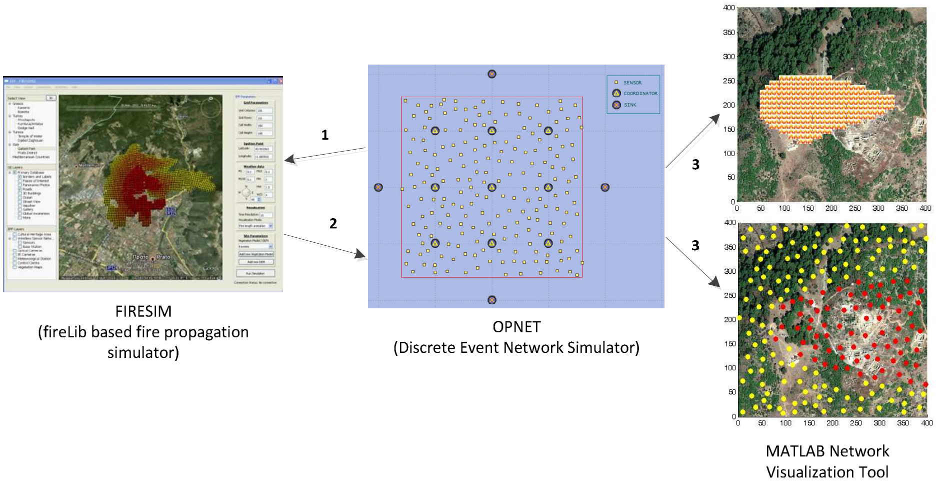

Figure 32: Integrated WSN performance evaluation system

Technical assessment of the FIRESENSE system

The test scenarios to evaluate the FIRESENSE system basically involved building an artificial fire which generates heat, smoke and visible flames, and the system components detecting this fire, hence allowing the evaluation of the system's fire detection performance. The control center software and the graphical user interface were utilized during the tests, and various visual and textual data gathered from the sensors were displayed and assessed.

The video-based smoke and fire detection performance was assessed in field tests organized in Rhodiapolis, Galceti, Temple of Water and Ankara. Fires of different sizes and at different distances from the cameras were set outdoors. Indoor tests with artificial smoke were also organized in Dodge Hall. In all cases, the system successfully detected smoke and flame and issued an early fire warning. The IR-based fire detection capabilities of the system were also evaluated in several tests organized in Belgium, Rhodiapolis and Galceti. The detection performance of MWIR, LWIR and SWIR cameras was assessed for fires at distances of upto 1 km in different environmental settings. The developed techniques have shown high detection accuracy and increased robustness to false positives caused by sunlight, moving objects, car lights, etc

The WSN-based fire detection system was evaluated in outdoor real fire tests conducted in Rhodiapolis, Dodge Hall, Ankara and Volos. The WSN sensors successfully detected temperature rise, while the proposed CUSUM-based methodology based on measurements obtained by clusters of sensors has shown increased robustness to false alarms caused by direct sunlight or ambient temperature rises.

The user-friendliness of the system and the control center user interface was assessed through questionnaires filled by system users. The users thought that the system is easy to use even by inexperienced personnel, its functionalities are clear and its interface is satisfactory.

A security evaluation of the system was also performed and conformity of subsystems to ISO/IEC 15408 was assessed. The FIRESENSE system uses an acceptable security scheme that uses subsystems which conform to the Common Criteria for data transmissions, and thus the eavesdropping from an adversary is very difficult. Nevertheless, the major concern of the FIRESENSE security scheme is to immediately detect system tampering or false data transmissions that can result in fire detection failures. This challenge has been addressed to both networking security and physical deployment level where practices that conform to ISO/IEC 15408 have been followed.

Finally, the system's performance, functionalities and compliance with user requirements and expectations were thoroughly evaluated by 54 people employed in fire service, forest service, cultural heritage organizations, local authorities and research institutions through detailed questionnaires filled during demonstration activities. In general, the users found the smoke and fire detection performance of the system mostly satisfactory. Another important conclusion is that most of the users gave high ratings for the quickness of the fire detection performance. From the user friendliness perspective, the system GUI is found to be mostly average, but also a significant portion of the users think that the system GUI is easy to use. On the overall, most of the participants think that the FIRESENSE system is a novel approach in cultural heritage and environmental monitoring and can be applied to other areas too. The most important result is that, a large majority of the participants are eager to apply the FIRESENSE system in their organizations if accompanied by professional support by system developers and researchers.

Publications & patents

Results from the research carried out within the FIRESENSE project have been published in international conferences and scientific journals. More specifically, 23 journal papers and 35 conference papers have been published or have been accepted for publication. These papers cover several research areas related to FIRESENSE technologies such as fire and smoke detection based on visible video, fire detection based on IR data processing, PIR-based flame detection, WSN architecture and design, WSN routing protocols, WSN activity scheduling, cooperative WSNs, vegetation classification based on satellite images, estimation and visualization of fire propagation, image fusion, multi-sensor data fusion, OPNET simulations, etc. A detailed list of these publications is presented in Table A1 of Section 4.2. Moreover, two patents for a) the PIR-based fire detection system and b) a smoke detection system using nonlinear video analysis were applied. These are presented in Table B1 of Section 4.2.

4.1.4 Potential impact

Natural hazards do not respect national boundaries; therefore, coordinated and collaborative research is required at the European level to reduce the uncertainty, the unpredictability and the consequences of natural hazards. Since the loss of a cultural heritage site is irreversible, there is great significance in integrating the technological components required for the protection of these sites. Archaeological sites located not only in the Mediterranean region but across Europe can greatly benefit from the FIRESENSE system.

The innovation of the FIRESENSE project capitalizes both on basic and emerging research directions that demonstrate strong potential, but are not established yet as an integrated solution. A significant outcome of the project is the development of new algorithms for outdoor fire and smoke detection using regular video, IR cameras and PIR sensors. Various algorithms were developed for real-time fire and smoke detection. Experimental results have shown that the developed algorithms are robust enough to false alarms and yet capable of detecting fire in its early stages. In addition, a novel multispectral image sensing platform including a visible, a SWIR and a LWIR camera was designed and implemented within FIRESENSE. Another significant outcome of the project is the design and development of a novel WSN for outdoor deployment that can operate on cheap-to-replace batteries for a long period, while maintaining a good response to sensing a wild fire. To this end, new WSN routing and activity scheduling protocols were designed and implemented as well.

Since the developed system is based on multi-sensor technology (optical cameras, IR (short and long wave) cameras, PIR sensors, wireless temperature and humidity sensors and meteorological sensors), novel data fusion techniques were proposed and developed to increase the reliability of the system. Furthermore, a new software platform for estimating fire propagation (EFP) based on weather data, Digital Terrain Models and fuel information was developed. Novel techniques based on multispectral satellite images were also developed for automatic vegetation classification. The EFP platform offers a user friendly interface, which allows 3D visualization of fire propagation on Google Earth maps. Finally, the FIRESENSE control centre provides various functionalities to the end users such as: video on demand from cameras, weather data, a local map of the supervised area along with the sensors' location, different levels of alarm etc.

The FIRESENSE project developed a powerful cost-efficient approach that can be used for the protection of cultural heritage providing:

- ***High reliability:*** The system utilizes different sensing technologies (CCTV cameras, PTZ cameras, IR cameras, PIR sensors, temperature and humidity sensors, and meteorological sensors). The different types of sensors operate independently
- ***Early detection of fire:*** Automatic detection of flame/smoke/rise in temperature.
- ***Forest fire management:*** The system estimates and visualizes the fire propagation based on the area's fuel model (vegetation), the local weather conditions and ground morphology.
- ***Automation of the fire fighting:*** The output of the FIRESENSE system can activate water

pipe networks for watering, like the fire sprinkler in buildings. Such water pipe networks are usually organized in sectors, which can be timely and separately activated in the areas threatened by the fire.

- ***Early warning for extreme weather conditions***: Local weather stations provide useful sensor readings like temperature, wind direction and speed, relative humidity, barometric pressure, rain gauge etc. External weather forecasting is made available to the system as well, which makes it straightforward to use it as an early warning system for extreme weather conditions.

Furthermore, two significant features of the FIRESENSE system, which make it applicable to numerous archaeological sites across Europe, are:

- **Modular architecture** that allows for easy system upgrades and extensions depending on the particular needs of different archaeological sites.
- Protection of archaeological sites through **non-destructive** and **non-intrusive intervention**.

Taking into account the technological benefits of the developed technology, the FIRESENSE project is expected to significantly contribute to the protection of forested areas and the safeguarding of cultural heritage, particularly monuments and open archaeological sites. Forest fires cause adverse ecological, economic and social impacts such as:

- Life casualties and loss of properties;
- Loss of valuable timber resources;
- Degradation of water catchment areas resulting in loss of water;
- Loss of biodiversity and extinction of plants and animals;
- Loss of wild life habitat and depletion of wild life;
- Loss of natural regeneration and reduction in forest cover and production;
- Global warming resulting in rising temperature;
- Loss of carbon sink resource and increase in percentage of CO_2 in the atmosphere;
- Change in the micro climate of the area resulting in unhealthy living conditions;
- Soil erosion affecting productivity of soils and agricultural production;
- Ozone layer depletion;
- Indirect effects on agricultural production;

Moreover, the proposed technology can be used in other sensitive areas and/or villages and towns located next to forests. As a result, the proposed system is expected to provide significant societal and economic benefits. More specifically, the FIRESENSE system will:

- locate high risk areas before the outbreak of fires and prevent human casualties and property losses;
- specify appropriate actions when facing forest fires, which can result in better management of resources and reduced loss of forested area;.
- protect forested areas of extreme cultural importance, which constitute a significant portion of the historical heritage in many European countries;
- have a positive contribution to environmental issues, as the forest fires are significant causes of air pollution, harmful carbon emissions, biodiversity loss through elimination of animal

and plant species and water supply problems;

- reduce losses for natural hazards and prevent man-made hazards (forest arsons) from happening;
- contribute to the protection of cultural heritage, the basic asset on which tourism is built. Tourism, closely related to Cultural Heritage, is, at the moment the main industry in the world, with an increasing ratio of 12% of the Gross Domestic Product (GDP). This sector employs 8 million people in Europe and accounts for nearly 5.5 % of European GDP.

The ***dissemination activities*** included a series of actions that provided third parties outside the consortium with information relevant to the project aiming to increase interest from stakeholders and support the exploitability of the FIRESENSE system. The dissemination activities of FIRESENSE include the following:

- Project logo
- Project brochure
- Web-site
- Posters
- FIRESENSE dissemination videos
- Video demos and the FIRESENSE video database for fire/smoke detection
- Press releases and TV interviews
- Events / meetings
- FIRESENSE Workshop
- Clustering activities and events
- User group establishment
- Education of inhabitants in pilot sites
- Publications in international journals and conferences

The main goal of these activities was to raise awareness about the protection of cultural heritage from natural disasters such as wildfires, disseminate the project's results, educate the inhabitants and exploit the FIRESENSE product.

A full list of FIRESENSE dissemination activities is presented in Table A2 of Section 4.2.

Project logo

The project logo presents the project scope and technology in the simplest way. The aim of the design is twofold: a) it emphasizes the use of sensor technology for early detection of fire, while b) the meander symbolises the protection of cultural heritage.

Figure 33: The FIRESENSE logo

Brochure

One of the first priorities in terms of dissemination was the preparation of the project brochure. The brochure was used to support project presentation in different events / meetings and has also served as a communication tool for potential mailings to groups of users. Except for the English version, the brochure was also translated and printed in Italian, French and Turkish.

Apart from providing an overview of the project consortium, and some contact information, the four-page brochure mainly focused on the project concept and aims, offering an overview of the overall architecture and modules. The pilot applications are presented as well. Having both end-user-oriented as well as technical content, the brochure is attractive for all target groups identified by the project. Several brochures were distributed to a large number of potential stakeholders. An electronic version of the brochure was also made available for download on the project website, and was provided in an accessible format.

Website

The FIRESENSE website is a tool for general dissemination activities presenting the project to the outside community and facilitating on-line collaboration between partners. The FIRESENSE website is reachable via the domain www.firesense.eu. It contains a public and a private part. The website is updated on a continuous basis by ITI-CERTH.

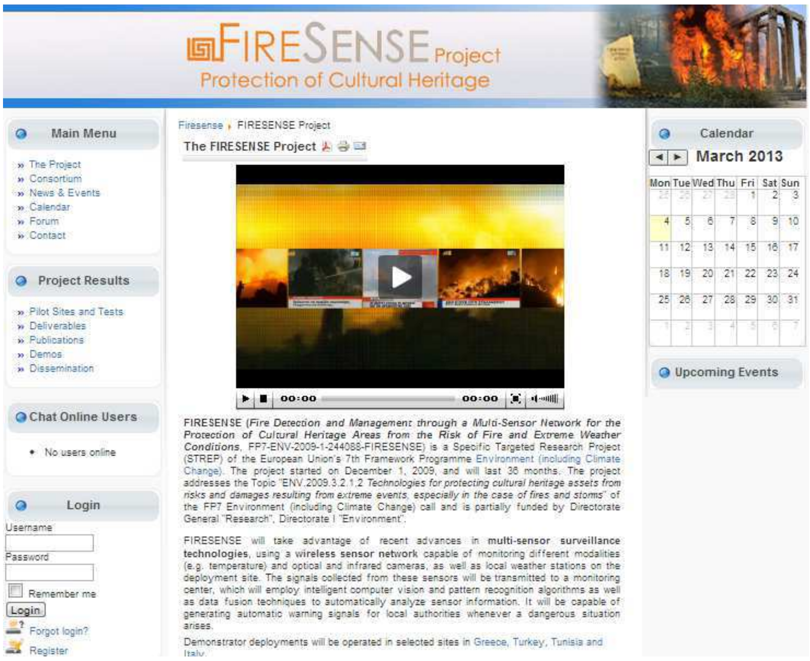

Figure 34: The FIRESENSE website

Posters

Posters were used at events such as exhibitions and international fairs in which partners participated. All posters followed a similar design approach. At the top of all posters there was the EU flag and the logo of both the FP7 and the Environment programmes, as well as the banner of the FIRESENSE website. An electronic version of all posters produced for dissemination purposes is available for download on the project website. The subjects of the designed posters include: a) general description of the FIRESENSE project, b) technical description of the FIRESENSE system and c) FIRESENSE technologies puzzle.

FIRESENSE dissemination videos

During the project, three videos (long, middle and short version) that demonstrate the objectives and results of FIRESENSE were created. These videos are available in a streaming format to the general public through the project's website and popular video-sharing websites. Videos were also delivered in CD or DVD format to all interested parties (EU, User Group, other potential users/buyers, etc.) and were also displayed in exhibitions, conferences and/or other dissemination activities. The main focus of this audiovisual material was to inform the broad public about the FIRESENSE overall benefits with respect to efficient fire detection and management for the protection of cultural heritage areas and demonstrate the advantages of the proposed multi-sensor system over existing technologies.

Figure 35: Screenshots from FIRESENSE video.

Press releases and TV Interviews

The dissemination activity of FIRESENSE includes the publishing of numerous press articles, interviews and press releases. These can be downloaded from the project website. Briefly, TV interviews, newspaper articles and articles in the web are presented below:

- TV interviews in Spanish, Italian, Greek and Turkish media
    - Interview of Nikos Grammalidis on CANAL PATRIMONIO, Spain (12/11/2010).
    - Press conference in Galceti park, Prato, Italy (10/6/2011)
        - Prato TV,
        - Toscana TV and
        - RTV38
    - Interview on ET3 - Greek National TV Channel (23/6/2011)
    - Interview on TRT Channel - Turkish Radio and Television (8/7/2011)
    - Documentary about Rhodiapolis on Turkish television channel NTV (23/7/2011)
    - News report on Turkish Channel 24 (5/7/2012)
- Articles in Greek, Turkish and Italian newspapers
    - Hurriyet (27 July 2010)
    - Il Tirreno Livorno (19 August 2010)
    - Aggelioforos (6 May 2011- Open Day CERTH-ITI)
    - Il Tirreno Prato (11 June 2011)
    - Antalya (5 July 2011)

    - Article in PARLIAMENT Magazine, Issue 335, pp. 57 October 2011
    - Milliyet Ankara (4 February 2013)

    etc.

- Articles and interviews that were released in Greek, Turkish and Italian web-sites
    - http://www.innovationseeds.eu/Virtual_Library/Results/FIRESENSE.kl#.UV7EzZM0zqj
    - http://www.csn.prato.it/modules/news/article.php?storyid=143
    - http://www.tvprato.it/archives/20505
    - http://phys.org/news/2013-02-firesense-cultural-heritage-monuments-hazards.html

    etc.

Events / meetings

FIRESENSE project and research achievements were presented in the following events / meetings:

- AR & PA Innovation (Valladolid, Spain, 11-14 November 2010 and 24-27 May 2012)
- Infosystem 2010 (Thessaloniki, Greece, 8 October, 2010)
- Open Day organized by ITI-CERTH (Thessaloniki, Greece, June 2010 & May 2011)
- Meeting of Prof. Enis Cetin with officers from the Turkish Directorate of Forestry (30 October 2011)
- Workshop organized by Prof. Enis Cetin and Prof. Ibrahim Korpeoglu during the URSI General Assembly and Scientific Symposium of International Union of Radio Science – (URSIGASS2011) (Istanbul, Turkey, 13-20 August 2011)
- Special session on "*Signal processing for disaster management and prevention*" organized by Prof. Enis Cetin and Dr. Nikos Grammalidis during the 19th European Signal Processing Conference (EUSIPCO2011) (Barcelona, Spain, 31 August 2011)
- Lecture on "*Flame detection and fire propagation estimation*" by Dr Kosmas Dimitropoulos (CERTH, Thessaloniki, Greece, 5 October 2011)
- Presentation about "*Supervised vegetation Classification for Fire Propagation Estimation*" to the United Nations/Vietnam Workshop on Space Technology Applications for Socio-Economic Benefits by Prof. Ferdaous Chaabane from SUPCOM (Hanoi, Vietnam,11 October 2011)
- 4th Archaeological Meeting of Thessaly and Central Greece (Volos, Greece, 15-18 March 2012)
- In the cultural association “Laios” by the director of THEPKA Mrs Alexandra Harami who talked about the archaeological site of Kabeirion (Thebes, Greece, 24 June 2012)
- 4th International Euro-Mediterranean Conference on Cultural Heritage (EuroMed 2012). A stand was used for presentation and dissemination of FIRESENSE. In this conference the paper "*Flame detection for video-based early fire warning for the protection of cultural heritage*" authored by K. Dimitropoulos,O. Gunay, K. Kose,F. Erden, F. Chaabene, F. Tsalakanidou, N. Grammalidis and E. Cetin was awarded with Best Full Paper Award (29 October - 3 November 2012, Lemesos, Cyprus).

Figure 36: a) The FIRESENSE stand at AR&PA event 2012, b) Participation in EUROMED 2012. The FIRESENSE team received the Best Full Paper Award for a paper on flame detection.

FIRESENSE Workshop

A two-day Workshop was organized in Antalya, Turkey on 8-9 November 2012 to disseminate and validate the FIRESENSE outcomes. The aim of the International Workshop on Multi-Sensor Systems and Networks for Fire Detection and Management was to bring together researchers from all over the world, who deal with fire detection and management using multi-media and multi-sensor devices and networks. A number of key stakeholders were invited; the Workshop was also open to all interested parties. The objective of this workshop was to widely disseminate the FIRESENSE concept and diffuse results achieved in pilot sites. Discussion about the validation of the FIRESENSE system and its exploitation strategy were also made.

A call for papers covering different areas related to fire detection and management was published on 31/07/2012. 12 papers were submitted and were presented in the Workshop in three regular sessions covering the following topics: i) "Video-based wildfire detection", ii)" Wireless Sensor Networks" and iii) "Wildfire prediction and readiness".

The Workshop also included presentations given by invited speakers from the Turkish General Directorate of Forestry, the Tunisian General Directorate of Forestry and the Greek Fire Service, as well as a presentation by an Italian expert in wildfire prediction.

Figure 37: FIRESENSE Workshop, Antalya, Turkey, 8-9 November 2012.

Clustering activities

The FIRESENSE consortium organized a clustering activity with representatives from BIOSOS, SCIER and FIREPARADOX EU projects on Friday 9 December 2011 in CERTH premises. The BIOSOS project was represented by Prof. Maria Petrou and Dr. Vasiliki Kosmidou. Prof. Maria Petrou was the Director of ITI-CERTH, while Dr. Kosmidou is a postdoctoral research fellow in ITI-

CERTH. The SCIER project was represented by Dr. Gavriil Xanthopoulos. Dr Xanthopoulos is a forest fire researcher at the Institute of Mediterranean Forest Ecosystems and Forest Products Technology of the National Agricultural Research Foundation in Athens, Greece. Finally, the FIREPARADOX project was represented by Dr Antonis Mantzavelas. Dr Mantzavelas is the manager of Omikron Ltd and President of the Permanent Committee for the Management of Forest Fires in Greece. The main topic of this event was the use of remote sensing technology for vegetation classification and fuel modeling. However, issues concerning fire detection technology and fire suppression techniques were discussed as well.

Furthermore, on 25th May 2012, the FIRESENSE project was presented at INTERVALUE (Inter-regional cooperation for valorization of R&D) project's Workshop. Finally, on 26th February 2013, a meeting was held between representatives of CERTH and representatives of the Greek national project "Forest Fire Prevention with INCA methodology" in order to investigate common interests and possible future collaboration.

User group

Potential users of FIRESENSE system and technologies can be classified in the following categories based on the type of organization they work for:

- Cultural heritage preservation/protection
- Civil protection
- Fire fighting
- Forest protection
- Environmental protection
- Volunteers
- Researchers

After establishing the user requirement group, the consortium focused on the establishment of a wider network of potential users. This network consists of users who can register through the project's web-site and participate in an on-going, two-way process. Within this process, the partners can publicize the results of their research, but they can also obtain feedback from potential users. At the end of the project the total number of registered users is 261 users from 49 different countries.

Education of inhabitants

Lectures were organized in test sites (Rhodiapolis, Kabeirion, Galceti Park and Temple of Water) to present the history of the sites, point out the importance of the conservation of the archaeological heritage and inform local inhabitants about the main objectives and results of the FIRESENSE project.

Prof. Enis Cetin visited Kumluca Vefa Hill High school in 2011 and 2012 to talk to students about the FIRESENSE project. This week was called "The Forest Week". Two concerts were organized in Rhodiapolis in the summer of 2011 and 2012, respectively. The chief archaeologist of the archaeological site Dr. Isa Kizgut gave talks to the concert attendees before the concerts and pointed out the he fact that wildfires are a major threat for cultural heritage treasures.

IX EPCA (HMC) organised educational programmes for three different categories of inhabitants: adults, school classes 9-12 years old and families with children. Specifically, three organised archaeological tours at the Temple of Kabeirion were conducted by Dr Vassilis Aravantinos, Director of the IX EPCA, at October 2010, and by Alexandra Charami, Directorin of the IX EPCA at April 2012 and June 2012 respectively.

Furthermore, special educational programmes for school classes (for children 9-12 years old) about the Temple of Kabeirion were conducted by IX EPCA on 14-21 May 2012 (International Museum Day), including informative presentations with power point, arts and crafts, and theatrical play.

Open weekend educational programmes for families were organized by IX EPCA on 21 May 2012 (International Museum Day) and on 21 October 2012, including informative presentation with power point, arts and crafts, and theatrical play. Finally, three lectures about the Temple of Kabeirion were presented by IX EPCA in May 2012, June 2012, and January 2013.

Lectures to local inhabitants at Galceti test site took place in December 2012. A parallel session was also organized by CNR in order to keep children busy in activities linked to the lecture theme, i.e. something linked to fire. In Tunisia, lectures were organized in January 2013 to inform Sup'Com undergraduate students about the Firesense project.

Figure 38: Photos from educational programmes and archaeological tours organized in Kabeirion, Thebes.

Publications

Results from the research carried out within the FIRESENSE project have been published in international conferences and scientific journals. FIRESENSE partners published 23 articles in peer-reviewed journals and 35 articles in conferences proceedings. A full list of FIRESENSE publications is presented in Table A1 of Section 4.2.

Exploitation

To facilitate the successful introduction of the proposed early fire warning system for the protection of cultural heritage and related applications into the market, detailed exploitation strategies were elaborated. The exploitation strategy analysis was initially based on internet data, products knowledge, system analysis and contacts with the distributor networks of Titan and Xenics. Around twenty different early fire detection applications were identified and studied. These helped the Consortium to define the market segments and identify the potential users of FIRESENSE technologies.

Moreover, to generate a more comprehensive picture of the market, its composition with respect to different user groups reflecting their particular expectations and needs, its takeover potential, market opportunities and barriers to adoption and related trends as well as the competitive environment were highlighted. More specifically, the following market segments were identified for possible application of the FIRESENSE technology:

- Archaeological sites
- Highways and railways going

- Museums fire protection
- Historic Buildings
- Art galleries fire protection
- Shops
- Parking fire Protection
- Tunnel fire protection
- Railways
- Metros
- City and Metros
- Nuclear Industry Plant
- Chemical Industry Plant
- Petrochemical
- Toxic material storage
- Logistics
- Offshore oil fire protection
- Gas infrastructure
- Pipe line infrastructure
- High voltage grids in forest areas
- Forest fire
- Waste fire
- Coal mine fire
- Waste treatment facilities
- Waste bunkers

through forests

- Satellite monitoring (image fusion – large areas)
- Aviation monitoring (image fusion – large areas)
- Helicopter monitoring (image fusion – large areas)
- UAV monitoring (image fusion – large areas)
- Pole and mast monitoring
- Integrated security and fire detection
- Critical Infrastructure
- Airports
- Ports
- Portable Firefighting
- Monitoring critical vessel temperature
- Torpedo Car Refractory Thermal Monitoring
- Fire detection for Traffic Monitoring
- Area of cement works

Furthermore, the security market was divided in two parts: the external security or defense (military) and the private security sector (private).

The integrators are also considered as potential customers, since they could integrate different parts of the FIRESENSE system (control centre, cameras, WSN, image processing, data fusion, fire propagation estimation software). In any case, the fire detection system architecture must be tuned in function of the application. The system includes basic blocks that should be integrated. Even if all the blocks are available to build a fire detection system, we need at the technical level the following competences: system engineering, project management, system integration, maintenance and training. More specifically, the system engineer will realize a step by step approach with iterative loops of the following phases: he will realize a thorough analysis with the end users of the mission taking into account the local context and organization. Before performing a survey analysis, he will realize an initial simulation and model based on geographic information system (GIS). After this first analysis, a detailed site survey will be conducted with the customer. A fine selection of the components such as the sensors, communication links, data bandwidth, power system and others will be defined and proposed. He will write the technical specification, the integration plan, the test plan and maintain the configuration management. A pilot network implementation for field testing with future operators of the system will be conducted for a first evaluation and a first tuning of a partial system. This will be followed by a full deployment of the overall system. The system engineer will also provide support to the end users during the preliminary phases.

The project manager will be responsible for the timely delivery of a high quality product and system. On the other hand, the system integrator will develop the large scale project in modular solutions by using the most appropriate sensors, communication system and computer systems. Finally, an

Integrated Logistic Support (ILS) ensures the maintainability of the system during its design and development. The ILS aims to address all the aspects of maintainability throughout the acquisition and whole life cycle of the equipment. Training should be provided to the customer.

Since cost of the equipment is one of the main criteria for successful market penetration, a cost analysis of sensors was also performed with emphasis on the IR cameras, which are the most expensive equipment of the system.

4.1.5 Project website

The website of the FIRESENSE project is www.firesense.eu. A screenshot of the home page can be seen below.

Figure 39: The homepage of the FIRESENSE website (www.firesense.eu)

Consortium

The FIRESENSE consortium consists of 10 partners (6 academic and research institutes, 3 SMEs and 1 state authority) from 6 countries:

- Centre for Research and Technology Hellas, Information Technologies Institute (Greece) - Coordinator
- Bilkent Universitesi (Turkey)
- Ecole Supérieure des Communication de Tunis (Tunisia)
- Xenics nv (Belgium)
- Stichting Centrum voor Wiskunde en Informatica (Netherlands)
- Marac Electronics S.A. (Greece)
- Bogazici Universitesi (Turkey)
- Hellenic Ministry of Culture, IX Ephorate for Prehistoric and Classical Antiquities (Greece)

- Titan Building Systems Technology, Industry and Trade Limited Company (Turkey)
- Consiglio Nazionale delle Ricerche (Italy)

Contact information

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Email: ngramm@iti.gr

4.2 Use and dissemination of foreground

A plan for use and dissemination of foreground (including socio-economic impact and target groups for the results of the research) shall be established at the end of the project. It should, where appropriate, be an update of the initial plan in Annex I for use and dissemination of foreground and be consistent with the report on societal implications on the use and dissemination of foreground (section 4.3 – H).

The plan should consist of:

- Section A

This section should describe the dissemination measures, including any scientific publications relating to foreground. **Its content will be made available in the public domain** thus demonstrating the added-value and positive impact of the project on the European Union.

- Section B

This section should specify the exploitable foreground and provide the plans for exploitation. All these data can be public or confidential; the report must clearly mark non-publishable (confidential) parts that will be treated as such by the Commission. Information under Section B that is not marked as confidential **will be made available in the public domain** thus demonstrating the added-value and positive impact of the project on the European Union.

Section A (public)

This section includes two templates

- Template A1: List of all scientific (peer reviewed) publications relating to the foreground of the project.
- Template A2: List of all dissemination activities (publications, conferences, workshops, web sites/applications, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters).

These tables are cumulative, which means that they should always show all publications and activities from the beginning until after the end of the project. Updates are possible at any time.

TEMPLATE A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES										
NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers[2] (if available)	Is/Will open access[3] provided to this publication?
	Journal papers									
1	*Video-based flame detection for the protection of Cultural Heritage*	*Kosmas Dimitropoulos*	*International Journal of Heritage in the Digital Era*	*Vol. 2, No 1, March 2013*	*Multi Science Publishing*	*UK*	*2013*	*pp. 23-47*	doi: 10.1260/2047-4970.2.1.23	yes
2	*Video Fire Detection - Review*	*A. Enis Cetin*	*Digital Signal Processing*	*To be published*	*Elsevier*	*Netherlands*	*2013*			yes
3	*A novel measurement-based approach for modeling and computation of interference*	*Alper Rifat Ulucinar*	*EURASIP Journal on Wireless Communications and*	*Vol. 2013, Article 68*	*Springer*	*Heidelberg, Germany*	*2013*		doi: 10.1186/1687-1499-2013-68	yes

[2] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).
[3] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

	factors for wireless channels		*Networking*						
4	*Fast saliency-aware multi-modality image fusion*	*Jungong Han*	*Neurocomputing*	*Vol.111, July 2013*	*Elsevier*	*Netherlands*	*2013*	*pp. 70-80*	doi: 10.1016/j.neucom.2012.12.015	yes
5	*Combined analysis of contention window size and duty cycle for throughput and energy optimization in wireless sensor networks*	*Mehmet Yunus Donmez*	*Computer Networks*	*Vol.57, No 5, April 2013*	*Elsevier*	*Netherlands*	*2013*	*pp. 1101–1112*	doi: 10.1016/j.comnet.2012.11.016	yes
6	*Moving shadow detection in video using Cepstrum*	*Fuat Cogun*	*International Journal of Advanced Robotic Systems*	*Vol. 10, No 18, 2013*	*InTech*	*Rijeka, Croatia*	*2013*		doi: 10.5772/52942	yes
7	*Visible and infrared image registration in man-made environments employing hybrid visual features*	*Jungong Han*	*Pattern Recognition Letters*	*Vol. 34, No 1, January 2013*	*Elsevier*	*Netherlands*	*2013*	*pp. 42-51*	doi: 10.1016/j.patrec.2012.03.022	yes
8	*A framework for use of wireless sensor networks in forest fire detection and monitoring*	*Yunus Emre Aslan*	*Computers, Environment and Urban Systems*	*Vol. 36, No 6, November 2012*	*Elsevier*	*Netherlands*	*2012*	*pp. 614-625*	doi: 10.1016/j.compenvurbsys.2012.03.002	yes
9	*Covariance matrix-based fire and flame detection method in video*	*Yusuf Hakan Habiboglu*	*Machine Vision and Applications*	*Vol. 23, No 6, November 2012*	*Springer-Verlag*	*Germany*	*2012*	*pp. 1103-1113*	doi: 10.1007/s00138-011-0369-1	yes
10	*Wavelet based flickering flame detector using differential PIR sensors*	*Fatih Erden*	*Fire Safety Journal*	*Vol. 53, October 2012*	*Elsevier*	*Netherlands*	*2012*	*pp. 13-18*	doi: 10.1016/j.firesaf.2012.06.006	yes
11	*PSAR: Power-Source-Aware Routing in ZigBee networks*	*Metin Tekkalmaz*	*ACM Wireless Networks*	*Vol. 18, No. 6, August 2012*	*Springer-Verlag*	*USA*	*2012*	*pp. 635-651*	doi: 10.1007/s11276-012-0424-5	yes
12	*Entropy functional based online adaptive decision fusion framework with application to wildfire detection in video*	*Osman Gunay*	*IEEE Transactions on Image Processing*	*Vol. 21, No 5, May 2012*	*IEEE*	*USA*	*2012*	*pp. 2853-2865*	doi: 10.1109/TIP.2012.2183141	yes
13	*Multi-sink load balanced forwarding with a multi-criteria fuzzy sink selection for video sensor networks*	*Sinan Isik*	*Computer Networks*	*Vol. 56, No 2, February 2012*	*Elsevier*	*Netherlands*	*2012*	*pp. 615-627*	doi: 10.1016/j.comnet.2011.10.010	yes
14	*Sink placement on a 3D terrain for border surveillance in wireless sensor networks*	*Rabun Kosar*	*Engineering Applications of Artificial Intelligence*	*Vol. 25, No 1, February 2012*	*Elsevier*	*Netherlands*	*2012*	*pp. 82-93*	doi: dx.doi.org/10.1016/j.engappai.201	yes

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15	*Scalable image quality assessment with 2D mel-cepstrum and machine learning approach*	*Manish Narwaria*	*Pattern Recognition*	*Vol. 45, No 1, January 2012*	*Elsevier*	*Netherlands*	*2012*	*pp. 299-313*	doi: 10.1016/j.patcog.2011.06.023	yes
16	*Superimposed event detection by particle filters*	*Onay Urfalioglu*	*IET Signal Processing*	*Vol. 5, No 7, October 2011*	*IET (Institution of Engineering and Technology)*	*UK*	*2011*	*pp. 662–668*	doi: 10.1049/iet-spr.2010.0022	yes
17	*A study of localization metrics: Evaluation of position errors in wireless sensor networks*	*Hidayet Aksu*	*Computer Networks*	*Vol. 55, No 15, October 2011*	*Elsevier*	*Netherlands*	*2011*	*pp. 3562-3577*	doi: 10.1016/j.comnet.2011.06.023	yes
18	*Design and implementation of a QoS-aware MAC protocol for Wireless Multimedia Sensor Networks*	*M. Aykut Yigitel*	*Computer Communications*	*Vol. 34, No 16, October 2011*	*Elsevier*	*Netherlands*	*2011*	*pp. 1991-2001*	doi: 10.1016/j.comcom.2011.06.006	yes
19	*OLSR-aware channel access scheduling in wireless mesh networks*	*Miray Kas*	*Journal of Parallel and Distributed Computing*	*Vol. 71, No 9, September 2011*	*Elsevier*	*Netherlands*	*2011*	*pp. 1225-1235*	doi: 10.1016/j.jpdc.2010.11.013	yes
20	*Online adaptive decision fusion framework based on projections onto convex sets with application to wildfire detection in video*	*Osman Gunay*	*Optical Engineering*	*Vol. 50, No 7, July 2011*	*SPIE*	*USA*	*2011*		doi :10.1117/1.3595426	yes
21	*QoS-aware MAC protocols for wireless sensor networks: A survey*	*M. Aykut Yigitel*	*Computer Networks*	*Vol. 55, No 8, June 2011*	*Elsevier*	*Netherlands*	*2011*	*pp. 1982-2004*	doi: 10.1016/j.comnet.2011.02.007	yes
22	*Cross layer load balanced forwarding schemes for video sensor networks*	*Sinan Isik*	*Ad Hoc Networks*	*Vol. 9, No 3, May 2011*	*Elsevier*	*Netherlands*	*2011*	*pp. 265-284*	doi: 10.1016/j.adhoc.2010.07.002	
23	*Sleep scheduling with expected common coverage in wireless sensor networks*	*Eyuphan Bulut*	*Wireless Networks*	*Vol. 17, No 1, January 2011*	*Springer US*	*USA*	*2011*	*pp. 19–40*	doi: 10.1007/s11276-010-0262-2	yes
	Conference papers									
24	*Flame detection for video-based early fire warning for the protection of Cultural*	*Kosmas Dimitropoulos*	*Proceedings 4th International Euro-Mediterranean*	*LNCS Vol. 7616, 2012*	*Springer-Verlag*	*Germany*	*2012*	*pp. 378-387*	doi: 10.1007/978-3-642-34234-9_38	yes

	Heritage		*Conference on Cultural Heritage (EuroMed 2012), Limassol, Cyprus, October 29 – November 3, 2012*							
25	*Performance Evaluation of Heterogeneous Wireless Sensor Networks for Forest Fire Detection*	*Can Tunca*	*Proceedings 21th IEEE Signal Processing and Communications Applications Conference (SIU2013), Girne, Cyprus, 24-26 April 2013*	*April 2013*	*IEEE*	*USA*	*2013*			*yes*
26	*Orman yangını tespiti amaçlı kablosuz algılayıcı ağların gerçekçi başarım değerlendirmesi için benzetim altyapısı ("A simulation platform for realistic performance evaluation of wireless sensor networks to detect forest fires")*	*Sinan. Isik*	*Proceedings Akademik Bilişim Konferansı (AB2013), Antalya, Turkey, 23-25 January 2013*	*AB2013, 2013*	*Akademik Bilişim Konferanslari*	*Turkey*	*2013*		http://ab.org.tr/ab13/bildiri/273.pdf	*yes*
27	*Archeological treasures protection based on early forest wildfire multi-band imaging detection system*	*Benedict Gouverneur*	*Proceedings SPIE Security & Defence 2012 - Conference 8541: Electro-Optical and Infrared Systems: Technology and Applications, Edinburgh, United Kingdom, 24 - 27 September 2012*	*Vol. 8541, October 2012*	*SPIE*	*USA*	*2012*		doi:10.1117/12.979659	no
28	*Early smoke detection in forest areas from DCT based compressed video*	*Amel Benazza-Benyahia*	*Proceedings 20th European Signal Processing Conference (EUSIPCO-2012), Bucharest, Romania, 27-31 August 2012*		*EURASIP*		*2012*	*pp. 2752-2756*	http://www.eurasip.org/Proceedings/Eusipco/Eusipco2012/Conference/papers/1569581559.pdf	yes
29	*Pixel and region based*	*Safa Rejichi*	*Proceedings IEEE*	*July 2012*	*IEEE*	*USA*	*2012*	*pp. 435 - 438*	doi:	yes

	temporal classification fusion for HR satellite image time series		*International Geoscience and Remote Sensing Symposium (IGARSS2012), Munich, Germany, 23-27 July 2012*						10.1109/IGARSS.2012.6351545	
30	*Flame detection for video-based early fire warning systems and 3D visualization of fire propagation*	*Kosmas Dimitropoulos*	*Proceedings 13th IASTED International Conference on Computer Graphics and Imaging (CGIM 2012), Crete, Greece, 18-20 June 2012*	*Vol. 779, 2012*	*ACTA Press*	*Canada*	*2012*		doi: 10.2316/P.2012.779-011	yes
31	*SUIT: A cross layer image transport protocol with fuzzy logic based congestion control for wireless multimedia sensor networks*	*Cagatay Sonmez*	*Proceedings 5th IFIP International Conference on New Technologies, Mobility and Security (NTMS2012), Istanbul, Turkey, 7-10 May 2012*	*May 2012*	*IEEE*	*USA*	*2012*		doi: 10.1109/NTMS.2012.6208750	yes
32	*Wavelet based flame detection using differential PIR sensors*	*F. Erden*	*Proceedings 20th IEEE Signal Processing and Communications Applications Conference (SIU2012), Fethiye, Mugla, Turkey, 18-20 April 2012*	*April 2012*	*IEEE*	*USA*	*2012*		doi: 10.1109/SIU.2012.6204529	yes
33	*Ring Routing: An energy-efficient routing protocol for wireless sensor networks with a mobile sink*	*Can Tunca*	*Proceedings 20th IEEE Signal Processing and Communications Applications Conference (SIU2012), Fethiye, Mugla, Turkey, 18-20 April 2012*	*April 2012*	*IEEE*	*USA*	*2012*		doi: 10.1109/SIU.2012.6204681	yes
34	*A cooperative communication protocol for saving energy consumption in WSNs*	*Mohamed Maalej*	*Proceedings 3rd IEEE International Conference on Communications and Networking (ComNet2012), Tunisia,*	*April 2012*	*IEEE*	*USA*	*2012*		doi: 10.1109/ComNet.2012.6217725	yes

			29 March-1 April 2012							
35	*FIRESENSE project at the pilot site of the Sanctuary of Kabireion, Thebes*	*Athina Papadaki*	*Proceedings of the 4th Archaeological Meeting of Thessaly and Central Greece (AETHSE), 15-18 March 2012, Volos, Greece*		*University of Thessaly*	*Volos, Greece*	*2013, In print*			no
36	*Multimodality and multiresolution image fusion*	*Paul M. de Zeeuw*	*Proceedings International Conference on Computer Vision Theory and Applications (VISAPP2012), Rome, Italy, February 2012 (ISBN 978-989-8565-03-7)*	*Vol. 1, February 2012*	*SciTePress*		*2012*	*pp. 151-157*	http://repository.cwi.nl/search/fullrecord.php?publnr=20289	yes
37	*Video based flame detection using spatio-temporal features and SVM classification*	*Kosmas Dimitropoulos*	*International Conference on Computer Vision Theory and Applications (VISAPP2012), Rome, Italy, February 2012 (ISBN 978-989-8565-03-7)*	*Vol. 1, February 2012*	*SciTePress*		*2012*	*pp. 453-456*		yes
38	*Visible and infrared image registration employing line-based geometric analysis*	*Jungong Han*	*Proceedings MUSCLE International Workshop on Computational Intelligence for Multimedia Understanding, Pisa, Italy, 13-15 December 2011*	*LNCS, Vol. 7252, 2011*	*Springer-Verlag Berlin Heidelberg*	*Germany*	*2011*	*pp. 114-125*	doi: 10.1007/978-3-642-32436-9_10	yes
39	*Multimodal monitoring of cultural heritage sites and the FIRESENSE project*	*Albert Ali Salah*	*Proceedings 4th International Symposium on Applied Sciences in Biomedical and Communication Technologies (ISABEL2011), Barcelona, Spain, 26-29*	*October 2011*	*ACM*	*USA*	*2011*		doi: 10.1145/2093698.2093850	yes

			October 2011							
40	SVM spatio-temporal vegetation classification using HR satellite images	Safa Rejichi	Proceedings SPIE Remote Sensing 2011 (Conference 8176: Sensors, Systems, and Next-Generation Satellites), 19-22 September 2011, Prague, Czech Republic	Vol. 8176, October 2011	SPIE	USA	2011		doi: 10.1117/12.898256	no
41	Earth observations for complementing vegetation definition and distribution: an example for fire propagation	Palma Blonda	Proceedings 2nd International Conference on Space Technology (ICST2011), 15-17 September 2011, Athens, Greece	September 2011	IEEE	USA	2011		doi: 10.1109/ICSpT.2011.6064650	yes
42	Détection de fumée dans des zones de foret à partir de séquences vidéo codées (Smoke detection in forest areas from encoded video sequences)	Noura Hamouda	Proceedings 23th GRETSI Symposium on Signal and Image Processing (GRETSI2011), 5-8 September 2011, Bordeaux, France	September 2011			2011		https://www2.lirmm.fr/lirmm/interne/BIBLI/CDROM/ROB/2011/GRETSI_2011/data/papers/c_benazza463.pdf	yes
43	One class classification for anomaly detection: Support Vector data description revisited	Eric J. Pauwels	Proceedings 11th Industrial Conference on Data Mining (ICDM2011), 30 August - 3 September 2011, New York, USA	LNCS Vol. 6870, September 2011	Springer-Verlag Berlin Heidelberg	Germany	2011	pp. 25-39	doi: 10.1007/978-3-642-23184-1_3	yes
44	Real-time wildfire detection using correlation descriptors	Yusuf Hakan Habiboglu	Proceedings 19th European Signal Processing Conference (EUSIPCO2011), 29 August - 2 September 2011, Barcelona, Spain	September 2011	EURASIP		2011	pp. 894-898	http://www.eurasip.org/Proceedings/Eusipco/Eusipco2011/papers/1569426605.pdf	yes
45	A multi-sensor network for the protection of Cultural Heritage	Nikos Grammalidis	Proceedings 19th European Signal	September 2011	EURASIP		2011	pp. 889-893	http://www.eurasip.org/Proceeding	yes

			Processing Conference (EUSIPCO2011), 29 August - 2 September 2011, Barcelona, Spain						s/Eusipco/Eusipco2011/papers/1569426915.pdf	
46	*Flame detection method in video using covariance descriptors*	*Yusuf Hakan Habibogllu*	*Proceedings 36th International Conference on Acoustics, Speech and Signal Processing (ICASSP2011), 22-27 May 2011, Prague, Czech Republic*	*May 2011*	*IEEE*	*USA*	*2011*	*pp. 1817 - 1820*	doi: 10.1109/ICASSP.2011.5946857	yes
47	*Fire detection, fuel model estimation and fire propagation estimation/visualization for the protection of Cultural Heritage*	*Dino Torri*	*Proceedings 6th International Congress of the European Society for Soil Conservation (ESSC) on "Innovative Strategies and Policies for Soil Conservation", 9-14 May 2011, Thessaloniki, Greece*	*May 2011*	*National Agricultural Research Foundation of Greece*	*Greece*	*2011*	*p. 107*	http://eusoils.jrc.ec.europa.eu/ESDB_Archive/eusoils_docs/Conf/6thESSC.pdf	yes
48	*The development of a multiband system for early detection of wildlife fires and indoor search and rescue operations*	*Benedict Gouverneur*	*Proceedings SPIE Defense, Security and Sensing 2011 (Conference 8029A: Sensing Technologies for Global Health, Military Medicine, Disaster Response, and 50Environmental Monitoring), 25-29 April 2011, Orlando, Florida, US*	*Vol. 8029A, paper 39, April 2011*	*SPIE*	*USA*	*2011*			no
49	*Fractional wavelet transform using an unbalanced lifting structure*	*Kivanc Kose*	*Proceedings SPIE Defense, Security and Sensing 2011 Conference*	*Vol. 8058 paper 4, April 2011*	*SPIE*	*USA*	*2011*		doi: 10.1117/12.882408	yes

			(Conference 8058: Independent Component Analyses, Wavelets, Neural Networks, Biosystems, and Nanoengineering IX), 25-29 April 2011, Orlando, Florida, US							
50	*Diff-MAC: A QoS-aware MAC protocol with differentiated services and hybrid prioritization for Wireless Multimedia Sensor Networks*	*M. Aykut Yigitel*	*Proceedings 6th International Symposium on QoS and Security for Wireless and Mobile Networks (Q2SWinet'10), 17-21 October 2010, Bodrum, Turkey*	*October 2010*	*ACM*	*USA*	*2010*	*pp. 62-69*	doi: 10.1145/1868630.1868642	yes
51	*Mel-Cepstral methods for image feature extraction*	*Serdar Cakir*	*Proceedings IEEE 17th International Conference on Image Processing (ICIP2010), 26-29 September 2010, Hong Kong*	*September 2010*	*IEEE*	*USA*	*2010*	*pp. 4577 - 4580*	doi: 10.1109/ICIP.2010.5652293	yes
52	*Content-adaptive color transform for image compression*	*Alexander Suhre*	*Proceedings IEEE 17th International Conference on Image Processing (ICIP2010), 26-29 September 2010, Hong Kong*	*September 2010*	*IEEE*	*USA*	*2010*	*pp. 189-192*	doi: 10.1109/ICIP.2010.5651034	yes
53	*Cepstrum based method for moving shadow detection in video*	*Fuat Cogun*	*Proceedings 25th International Symposium on Computer and Information Sciences (ISCIS2010), 22-24 September 2010, London, UK*	*LNEE Vol. 62, September 2010*	*Springer Netherlands*	*Netherlands*	*2010*	*pp. 299-304*	doi: 10.1007/978-90-481-9794-1_57	yes
54	*Two-Dimensional Mellin and Mel-Cepstrum for Image Feature Extraction*	*Serdar Cakir*	*Proceedings 25th International Symposium on Computer and*	*LNEE Vol. 62, September 2010*	*Springer Netherlands*	*Netherlands*	*2010*	*pp. 271-276*	doi: 10.1007/978-90-481-9794-1_52	yes

			Information Sciences (ISCIS2010), 22-24 September 2010, London, UK							
55	*Image feature extraction using 2D Mel-Cepstrum*	*Serdar Cakir*	*Proceedings International Conference on Pattern Recognition (ICPR2010), 23-26 August 2010, Istanbul, Turkey*	*August 2010*	*IEEE*	*USA*	*2010*	*pp. 674-677*	doi: 10.1109/ICPR.20 10.170	yes
56	*Fire detection and 3D fire propagation estimation for the protection of Cultural Heritage areas*	*Kosmas Dimitropoulos*	*Proceedings ISPRS Technical Commission VIII Symposium, 9-12 August 2010, Kyoto, Japan*	*ISPRS Archives, Vol. XXXVIII, Part 8, August 2010*	*International Society for Photogramm etry and Remote Sensing (ISPRS)*	*Austria*	*2010*	*pp. 620-625*	http://www.isprs. org/proceedings/ XXXVIII/part8/he adline/TS- 20/W07F04_201 00301221108.pdf	yes
57	*Image compression using a histogram-based color transform*	*Alexander Suhre*	*Proceedings IEEE 18th Signal Processing and Communications Applications Conference (SIU2010), 22-24 April 2010, Diyarbakir, Turkey*	*April 2010*	*IEEE*	*USA*	*2010*	*pp. 344-347*	doi: 10.1109/SIU.201 0.5654366	yes
58	*VOC gas leak detection using Pyro-electric Infrared sensors*	*F. Erden*	*35th IEEE International Conference on Acoustics Speech and Signal Processing (ICASSP2010), 14-19 March 2010, Dallas, Texas, USA*	*March 2010*	*IEEE*	*USA*	*2010*	*pp. 1682 - 1685*	doi: 10.1109/ICASSP .2010.5495500	yes

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[4]	Main leader	Title	Date/Period	Place	Type of audience[5]	Size of audience	Countries addressed
1	*Publication*	*CERTH*	*Video-based flame detection for the protection of Cultural Heritage*	*March 2013*	*International Journal of Heritage in the Digital Era, Vol. 2, No 1, pp. 23-47*	*Scientific Community*		*International*
2	*Publication*	*BILKENT*	*Video Fire Detection - Review*	*2013*	*Elsevier Digital Signal Processing*	*Scientific Community*		*International*
3	*Publication*	*BILKENT*	*A novel measurement-based approach for modeling and computation of interference factors for wireless channels*	*2013*	*EURASIP Journal on Wireless Communications and Networking, Vol. 2013*	*Scientific Community*		*International*
4	*Publication*	*CWI*	*Fast saliency-aware multi-modality image fusion*	*July 2013*	*Elsevier Neurocomputing, Vol. 111*	*Scientific Community*		*International*
5	*Publication*	*BOGAZICI*	*Combined analysis of contention window size and duty cycle for throughput and energy optimization in wireless sensor networks*	*April 2013*	*Elsevier Computer Networks, Vol.57, No 5*	*Scientific Community*		*International*

[4] A drop down list allows choosing the dissemination activity: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters, Other.

[5] A drop down list allows choosing the type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias, Other ('multiple choices' is possible).

6	*Publication*	*BILKENT*	*Moving shadow detection in video using Cepstrum*	*2013*	*International Journal of Advanced Robotic System, Vol. 10, No 18*	*Scientific Community*		*International*
7	*Publication*	*CWI*	*Visible and infrared image registration in man-made environments employing hybrid visual features*	*January 2013*	*Elsevier Pattern Recognition Letter, Vol. 34, No 1*	*Scientific Community*		*International*
8	*Publication*	*BILKENT*	*A framework for use of wireless sensor networks in forest fire detection and monitoring*	*November 2012*	*Elsevier Computers, Environment and Urban Systems, Vol. 36, No Vol. 36, No 6*	*Scientific Community*		*International*
9	*Publication*	*BILKENT*	*Covariance matrix-based fire and flame detection method in video*	*November 2012*	*Machine Vision and Applications, Vol. 23, No 6*	*Scientific Community*		*International*
10	*Publication*	*BILKENT*	*Wavelet based flickering flame detector using differential PIR sensors*	*October 2012*	*Elsevier Fire Safety Journal, Vol. 53*	*Scientific Community*		*International*
11	*Publication*	*BILKENT*	*PSAR: Power-Source-Aware Routing in ZigBee networks*	*August 2012*	*ACM Wireless Network, Vol. 18, No. 6*	*Scientific Community*		*International*
12	*Publication*	*BILKENT*	*Entropy functional based online adaptive decision fusion framework with application to wildfire detection in video*	*May 2012*	*IEEE Transactions on Image Processing, Vol. 21, No 5*	*Scientific Community*		*International*
13	*Publication*	*BOGAZICI*	*Multi-sink load balanced forwarding with a multi-criteria fuzzy sink selection for video sensor networks*	*February 2012*	*Elsevier Computer Network, Vol. 56, No 2*	*Scientific Community*		*International*

14	*Publication*	*BOGAZICI*	*Sink placement on a 3D terrain for border surveillance in wireless sensor networks*	*February 2012*	*Elsevier Engineering Applications of Artificial Intelligence, Vol. 25, No 1*	*Scientific Community*		*International*
15	*Publication*	*BILKENT*	*Scalable image quality assessment with 2D mel-cepstrum and machine learning approach*	*January 2012*	*Elsevier Pattern Recognition, Vol. 45, No 1*	*Scientific Community*		*International*
16	*Publication*	*BILKENT*	*Superimposed event detection by particle filters*	*October 2011*	*IET Signal Processing, Vol. 5,* *No 7*	*Scientific Community*		*International*
17	*Publication*	*BILKENT*	*A study of localization metrics: Evaluation of position errors in wireless sensor networks*	*October 2011*	*Elsevier Computer Networks, Vol. 55, No 15*	*Scientific Community*		*International*
18	*Publication*	*BOGAZICI*	*Design and implementation of a QoS-aware MAC protocol for Wireless Multimedia Sensor Networks*	*October 2011*	*Elsevier Computer Communications, Vol. 34, No 16*	*Scientific Community*		*International*
19	*Publication*	*BILKENT*	*OLSR-aware channel access scheduling in wireless mesh networks*	*September 2011*	*Elsevier Journal of Parallel and Distributed Computing, Vol. 71, No 9*	*Scientific Community*		*International*
20	*Publication*	*BILKENT*	*Online adaptive decision fusion framework based on projections onto convex sets with application to wildfire detection in video*	*July 2011*	*SPIE Optical Engineering, Vol. 50, No 7*	*Scientific Community*		*International*
21	*Publication*	*BOGAZICI*	*QoS-aware MAC protocols for wireless sensor networks: A survey*	*June 2011*	*Elsevier Computer Networks, Vol. 55, No 8*	*Scientific Community*		*International*

22	*Publication*	*BOGAZICI*	*Cross layer load balanced forwarding schemes for video sensor networks*	*May 2011*	*Elsevier Ad Hoc Networks, Vol. 9, No 3*	*Scientific Community*		*International*
23	*Publication*	*BILKENT*	*Sleep scheduling with expected common coverage in wireless sensor networks*	*January 2011*	*Wireless Networks Journal, Vol. 17, No 1*	*Scientific Community*		*International*
24	*Conference*	*BOGAZICI*	*21th IEEE Signal Processing and Communications Applications Conference (SIU2013)*	*24-26 April 2013*	*Girne, Cyprus*	*Scientific Community*		*International*
25	*Conference*	*BOGAZICI*	*Akademik Bilişim Konferansı 2013*	*23-25 January 2013*	*Antalya, Turkey*	*Scientific Community*		*Turkey*
26	*Conference*	*CERTH*	*4th International Euro-Mediterranean Conference on Cultural Heritage (EuroMed 2012)*	*29 October – 3 November 2012*	*Limassol, Cyprus*	*Scientific Community*	*40*	*International*
27	*Conference*	*XENICS*	*SPIE Security & Defence 2012 - Conference 8541: Electro-Optical and Infrared Systems: Technology and Applications*	*24 - 27 September 2012*	*Edinburgh, United Kingdom*	*Scientific Community, Industry*		*International*
28	*Conference*	*SUPCOM*	*20th European Signal Processing Conference (EUSIPCO-2012)*	*27-31 August 2012*	*Bucharest, Romania*	*Scientific Community*	*40*	*Europe*
29	*Workshop*	*SUPCOM*	*International Geoscience and Remote Sensing Symposium (IGARSS2012)*	*23-27 July 2012*	*Munich, Germany*	*Scientific Community*	*40*	*International*

30	*Conference*	*CERTH*	*13th IASTED International Conference on Computer Graphics and Imaging (CGIM 2012)*	*18-20 June 2012*	*Crete, Greece*	*Scientific Community*	*40*	*International*
31	*Conference*	*BOGAZICI*	*5th IFIP International Conference on New Technologies, Mobility and Security (NTMS2012), Istanbul, Turkey, 7-10 May 2012*			*Scientific Community*		*International*
32	*Conference*	*BILKENT*	*20th IEEE Signal Processing and Communications Applications Conference (SIU2012)*	*18-20 April 2012*	*Fethiye, Mugla, Turkey*	*Scientific Community*		*Turkey*
33	*Conference*	*BOGAZICI*	*20th IEEE Signal Processing and Communications Applications Conference (SIU2012)*	*18-20 April 2012*	*Fethiye, Mugla, Turkey*	*Scientific Community*		*Turkey*
34	*Conference*	*SUPCOM*	*3rd IEEE International Conference on Communications and Networking (ComNet2012)*	*29 March-1 April 2012*	*Hammamet, Tunisia*	*Scientific Community*	*50*	*International*
35	*Conference*	*HMC*	*4th Archaeological Meeting of Thessaly and Central Greece (AETHSE)*	*15-18 March 2012*	*Volos, Greece*	*Scientific Community*		*Greece*
36	*Conference*	*CWI*	*International Conference on Computer Vision Theory and Applications (VISAPP2012)*	*24-26 February 2012*	*Rome, Italy*	*Scientific Community*		*International*

37	Conference	CERTH	International Conference on Computer Vision Theory and Applications (VISAPP2012)	24-26 February 2012	Rome, Italy	Scientific Community	40	International
38	Workshop	CWI	MUSCLE International Workshop on Computational Intelligence for Multimedia Understanding	13-15 December 2011	Pisa, Italy	Scientific Community		International
39	Workshop	CWI	4th International Symposium on Applied Sciences in Biomedical and Communication Technologies (ISABEL2011)	26-29 October 2011	Barcelona, Spain	Scientific Community		International
40	Workshop	SUPCOM	United Nations/Vietnam Workshop on Space Technology Applications for Socio-Economic Benefits	10 - 14 October 2011	Hanoi, Vietnam	Scientific Community	60	International
41	Conference	SUPCOM	SPIE Remote Sensing 2011 - Conference 8176: Sensors, Systems, and Next-Generation Satellites)	19-22 September 2011	Prague, Czech Republic	Scientific Community	30	International
42	Conference	CNR	2nd International Conference on Space Technology (ICST2011)	15-17 September 2011	Athens, Greece	Scientific Community		International
43	Workshop	SUPCOM	23th GRETSI Symposium on Signal and Image Processing (GRETSI2011)	5-8 September 2011	Bordeaux, France	Scientific Community	20	France, International
44	Conference	CWI	11th Industrial Conference on Data Mining (ICDM2011)	30 August - 3 September 2011	New York, USA	Scientific Community, Industry		International

45	Conference	BILKENT	19th European Signal Processing Conference (EUSIPCO2011)	29 August - 2 September 2011	Barcelona, Spain	Scientific Community	40	International
46	Conference	CERTH	19th European Signal Processing Conference (EUSIPCO2011)	29 August - 2 September 2011	Barcelona, Spain	Scientific Community	40	International
47	Conference	BILKENT	36th International Conference on Acoustics, Speech and Signal Processing (ICASSP2011)	22-27 May 2011	Prague, Czech Republic	Scientific Community		International
48	Conference	CNR	6th International Congress of the European Society for Soil Conservation (ESSC) on "Innovative Strategies and Policies for Soil Conservation"	9-14 May 2011	Thessaloniki, Greece	Scientific Community	40	Europe
49	Conference	XENICS	SPIE Defense, Security and Sensing 2011 - Conference 8029A: Sensing Technologies for Global Health, Military Medicine, Disaster Response, and Environmental Monitoring	25-29 April 2011	Orlando, Florida, US	Scientific Community, Industry		International
50	Conference	BILKENT	SPIE Defense, Security and Sensing 2011 Conference - Conference 8058: Independent Component Analyses, Wavelets, Neural Networks, Biosystems, and Nanoengineering IX	25-29 April 2011	Orlando, Florida, US	Scientific Community, Industry		International

51	Workshop	BOGAZICI	6th International Symposium on QoS and Security for Wireless and Mobile Networks (Q2SWinet'10)	17-21 October 2010	Bodrum, Turkey	Scientific Community		International
52	Conference	BILKENT	IEEE 17th International Conference on Image Processing (ICIP2010) (paper 1)	26-29 September 2010	Hong Kong	Scientific Community		International
53	Conference	BILKENT	IEEE 17th International Conference on Image Processing (ICIP2010) (paper 2)	26-29 September 2010	Hong Kong	Scientific Community		International
54	Workshop	BILKENT	25th International Symposium on Computer and Information Sciences (ISCIS2010) (paper 1)	22-24 September 2010	London, UK	Scientific Community		International
55	Workshop	BILKENT	25th International Symposium on Computer and Information Sciences (ISCIS2010) (paper 2)	22-24 September 2010	London, UK	Scientific Community		International
56	Conference	BILKENT	International Conference on Pattern Recognition (ICPR2010)	23-26 August 2010	Istanbul, Turkey	Scientific Community		International
57	Workshop	CERTH	ISPRS Technical Commission VIII Symposium	9-12 August 2010	Kyoto, Japan	Scientific Community	40	International
58	Conference	BILKENT	IEEE 18th Signal Processing and Communications Applications Conference (SIU2010)	22-24 April 2010	Diyarbakir, Turkey	Scientific Community		Turkey

59	Conference	BILKENT	35th IEEE International Conference on Acoustics Speech and Signal Processing (ICASSP2010)	14-19 March 2010	Dallas, Texas, USA	Scientific Community		International
60	Film	CERTH	FIRESENSE Video - Small version - Medium version - Large version	February 2013	Presented in FIRESENSE workshop and several dissemination events organized for system demonstration Can be found in the project website: http://www.firesense.eu/index.php?option=com_content&view=article&id=108%3Afiresense-video&catid=3%3Anews&Itemid=2&lang=en and YouTube: http://www.youtube.com/watch?v=37pfhpAG-Ks	Scientific Community, Civil Society, Policy makers, Industry, Other		International
61	Web	CERTH	FIRESENSE web-site	Released in December 2009	www.firesense.eu	Scientific Community, Civil Society, Policy makers, Industry, Other	12,074	International
62	Web	BILKENT	Bilkent FIresense webpage	Released in February 2010	http://signal.ee.bilkent.edu.tr/FIRESENSE.html	Scientific Community		Turkey
63	Web	BOGAZICI	Bogazici Firesense webpage	Released in February 2010	http://netlab.boun.edu.tr/firesense	Civil Society, Scientific Community, Medias		Turkey
64	Web	CNR	CSN: scientific activities	Released in January 2010	http://www.csn.prato.it/modules/smartsection/item.php?itemid=9	Scientific Community, Civil Society, Policy makers, Industry, Other		Italy

65	Web	CNR	*FIRESENSE web site for Italian stake-holders and for dissemination purposes*	*Released in August 2012*	http://firesense.irpi.cnr.it/	*Scientific Community,* *Civil Society, Policy makers, Industry,* *Other*		*Italy*
66	Web	CERTH	*FIRESENSE: New system could be best protection for cultural heritage monuments against fire, other hazards*	*21 February 2013*	*http://phys.org/*	*Scientific Community*		*International*
67	Web	BILKENT	*Rhodiapolis*	*12 March 2013*	*https://en.wikipedia.org/wiki/ Rhodiopolis*	*Civil Society*		*International*
68	Web	BILKENT	*Rhodiopolis Antik Kenti Canlı (The ancient city of Rhodiapolis live)*		*http://www.kumluca.gov.tr/*	*Civil Society*	*21,7827*	*Turkey*
69	Web	BILKENT	*EEE Professor and Students Win "Best Paper" Award at UNESCO Conference on Cultural Heritage Preservation*	*6 November 2012*	*http://bilnews.bilkent.edu.tr/issue_19_7/EEE.html*	*Scientific Community*		*Turkey*
70	Web	CERTH	*The FIRESENSE project*	*2013*	http://www.innovationseeds.eu			*Europe*
71	Web	CNR/CSN	*Conferenza stampa del progetto "FireSense" (Press conference of FireSense project)*	*10 June 2011*	*http://www.csn.prato.it/*	*Civil Society*		*Italy*

72	Web	CNR	Al CSN un sistema di videocamere per la sorveglianza anti-incendio (A videocamera system for fire protection installed in CSN)	11 June 2011	http://www.tvprato.it/	Civil Society		Italy
73	Web	HMC	FIRESENSE system in operation in the Sanctuary of Kabeirion!	3 February 2013	http://thivagr.blogspot.gr	Civil Society		Greece
74	Flyer	CERTH	FIRESENSE brochure in English	April 2010	Greece	Scientific Community, Civil Society, Policy makers, Industry, Other		International
75	Flyer	BILKENT	FIRESENSE brochure in Turkish	April 2010	Turkey	Scientific Community, Civil Society, Policy makers, Industry, Other		Turkey
76	Flyer	SUPCOM	FIRESENSE brochure in French	April 2010	Tunisia	Scientific Community, Civil Society, Policy makers, Industry, Other		Tunisia
77	Flyer	CNR	FIRESENSE brochure in Italian	April 2010	Italy	Scientific Community, Civil Society, Policy makers, Industry, Other		Italy

78	Flyer	CERTH	FIRESENSE EU Fact Sheet	May 2010	Brussels, Belgium	Scientific Community, Civil Society, Policy makers, Industry		International
79	Flyer	CERTH	FIRESENSE leaflet in English	April 2010	Greece	Scientific Community, Civil Society, Industry		International
80	Flyer	CERTH	FIRESENSE leaflet in Greek	April 2010	Greece	Scientific Community, Civil Society, Industry		Greece
81	Articles published in the popular press	CERTH	Hi-tech protection of cultural heritage	27 February 2011	Aggelioforos Newspaper, Thessaloniki, Greece	Medias	1,000,0 00	Greece
82	Articles published in the popular press	CERTH	Visitors day in ITI-CERTH	6 May 2011	Aggelioforos Newspaper, Thessaloniki, Greece	Medias	1,000,0 00	Greece
83	Articles published in the popular press	CERTH	Innovative project for the protection of archaeological monuments,	11 May 2011	Avriani Newspaper, Thessaloniki, Greece	Medias	1,000,0 00	Greece
84	Articles published in the popular press	CERTH	Fire prevention in cultural heritage sites	15 May 2011	Avriani Newspaper, Thessaloniki, Greece	Medias	1,000,0 00	Greece
85	Articles published in the popular press	BILKENT	Early-warning system installed to protect ancient Turkish cities	27 July 2010	Hurriyet newspaper, Turkey	Civil Society		Turkey

86	*Articles published in the popular press*	*BILKENT*	*Orman alanları gözetleniyor (Forests are monitored)*	*5 July 2011*	*Akdeniz Beyaz Newspaper, Turkey*	*Civil Society*	*5,500*	*Turkey*
87	*Articles published in the popular press*	*BILKENT*	*Ormanlar ve antik kentler kamerayla gözetleniyor (Forests and ancient cities are monitored with cameras)*	*5 July 2011*	*Akdeniz Guncel Newspaper, Turkey*	*Civil Society*	*1,045*	*Turkey*
88	*Articles published in the popular press*	*BILKENT*	*Antik kentler gözetleniyor (Ancient cities are monitored)*	*5 July 2011*	*Akdeniz Manset Newspaper, Turkey*	*Civil Society*	*1,073*	*Turkey*
89	*Articles published in the popular press*	*BILKENT*	*Avrupa da uygulayacak (Europe will utilize too)*	*5 July 2011*	*Akdenizde Yeni Yuzyl Newspaper, Turkey*	*Civil Society*	*1,043*	*Turkey*
90	*Articles published in the popular press*	*BILKENT*	*Ormanlar ve antik kentler gözaltında (Forests and ancient cities are monitored)*	*5 July 2011*	*Antalya Ekspres Newspaper, Turkey*	*Civil Society*	*1,071*	*Turkey*
91	*Articles published in the popular press*	*BILKENT*	*Antik kentler gözetleniyor (Ancient cities are monitored)*	*5 July 2011*	*Antalya Gundem Newspaper, Turkey*	*Civil Society*	*1,051*	*Turkey*
92	*Articles published in the popular press*	*BILKENT*	*Biri ormanları gözetliyor (Forest Big brother)*	*5 July 2011*	*Antalya Korfez Newspaper, Turkey*	*Civil Society*	*2,000*	*Turkey*
93	*Articles published in the popular press*	*BILKENT*	*Orman yangınlarına karşı erken uyarı sistemi (Early warning system against wildfires)*	*5 July 2011*	*Antalya Newspaper, Turkey*	*Civil Society*	*1,011*	*Turkey*

94	Articles published in the popular press	BILKENT	Ormanlara kameralı güvenlik geliyor (Camera enhanced security will be deployed in forests)	5 July 2011	Gercek Akdeniz Newspaper, Turkey	Civil Society	1,152	Turkey
95	Articles published in the popular press	BILKENT	Ormanlara kameralı takip (Camera surveillance for forests)	5 July 2011	Hurses Antalya Newspaper, Turkey	Civil Society	1,037	Turkey
96	Articles published in the popular press	BILKENT	Orman alanları ve antik kentler kamerayla gözetleniyor (Forests and ancient cities are monitored with cameras)	5 July 2011	Zaman Antalya Newspaper, Turkey	Civil Society	870,649	Turkey
97	Articles published in the popular press	BILKENT	Duman beklemeden haber verecek (System will notify without sensing smoke)	4 February 2013	Anadolu Manset Newspaper, Turkey	Civil Society	530	Turkey
98	Articles published in the popular press	BILKENT	Duman beklemeden haber verecek (System will notify without sensing smoke)	4 February 2013	Anadolu Telgraf Newspaper, Turkey	Civil Society	950	Turkey
99	Articles published in the popular press	BILKENT	Dumandan once alevi algılayan sensor! (Sensor that detects fire before detecting smoke)	04 February 2013	Bugun Newspaper, Turkey	Civil Society	106,512	Turkey
100	Articles published in the popular press	BILKENT	Bilkent'ten bir ilk (A first from Bilkent)	4 February 2013	Cumhuriyet Ankara Newspaper, Turkey	Civil Society	50,399	Turkey
101	Articles published in the popular press	BILKENT	Bilkent'ten yagına karşı önemli buluş (Important invention from Bilkent against fires)	4 February 2013	Haberturk Ankara Newspaper, Turkey	Civil Society	206,078	Turkey

102	Articles published in the popular press	BILKENT	Dumanı beklemeden yangını haber Veriyor (System will notify without sensing smoke)	4 February 2013	Hurriyet Ankara Newspaper, Turkey	Civil Society	392,791	Turkey
103	Articles published in the popular press	BILKENT	Bilkent'ten bir ilk daha (Another first from Bilkent)	4 February 2013	Milliyet Ankara Newspaper, Turkey	Civil Society	151,283	Turkey
104	Articles published in the popular press	BILKENT	Bilkent'ten en hızlı dedektör (Fastest detector from Bilkent)	4 February 2013	Radikal Newspaper, Turkey	Civil Society	24,930	Turkey
105	Articles published in the popular press	BILKENT	'Harekete duyarlı' yangın sensörü ('Motion sensing' fire detector)	4 February 2013	Sabah Newspaper, Turkey	Civil Society	32,1955	Turkey
106	Articles published in the popular press	BILKENT	Duman olmadan yangını görecek(System will notify without smoke)	4 February 2013	Star Newspaper, Turkey	Civil Society	135,151	Turkey
107	Articles published in the popular press	BILKENT	Yangına karşı yeni system (New system against fire)	4 February 2013	Takvim Newspaper, Turkey	Civil Society	10,6373	Turkey
108	Articles published in the popular press	BILKENT	Dumano görmeden yangını bildiriyor (System will notify without sensing smoke)	4 February 2013	Vatan Newspaper, Turkey	Civil Society	112,717	Turkey
109	Articles published in the popular press	BILKENT	Dumanı beklemeden yangını haber veren system (System will notify without sensing smoke)	4 February 2013	Yeni Akit Newspaper, Turkey	Civil Society	50,113	Turkey

110	*Articles published in the popular press*	*BILKENT*	*Dumanı beklemeden haber verecek (System will notify without sensing smoke)*	*4 February 2013*	*Yeni Konya*	*Civil Society*	*587*	*Turkey*
111	*Articles published in the popular press*	*BILKENT*	*Dumanı beklemeden yangını haber veren system (System will notify without sensing smoke)*	*4 February 2013*	*Yeni Safak Newspaper, Turkey*	*Civil Society*	*10,0629*	*Turkey*
112	*Articles published in the popular press*	*BILKENT*	*Doğal Yaşama Teknoloji Koruması (Technological protection for wildlife)*	*December 2012*	*Dergi Bilkent Newspaper, Turkey*	*Civil Society*	*30,000*	*Turkey*
113	*Articles published in the popular press*	*BILKENT*	*EEE Professor and Students Win "Best Paper" Award*	*6 November 2012*	*Bilnews Newspaper, Turkey*	*Scientific Community*		*Turkey*
114	*Articles published in the popular press*	*SUPCOM*	*FIRESENSE project*	*18 January 2013*	*Assabah Newspaper, Tunisia*	*Civil Society*		*Tunisia*
115	*Articles published in the popular press*	*SUPCOM*	*FIRESENSE project*	*26 January 2013*	*Assabah Newspaper, Tunisia*	*Civil Society*		*Tunisia*
116	*Articles published in the popular press*	*SUPCOM*	*FIRESENSE project*	*7 December 2012*	*Webmanagercenter, Tunisia*	*Civil Society*		*Tunisia*
117	*Articles published in the popular press*	*BOGAZICI*	*Tarihi eserlere, yangın ve sele karşı kızılötesi koruma (Infrared protection against fire and flood forhistorical monuments)*	*3 January 2010*	*Haberturk newspaper, Turkey*	*Civil Society*		*Turkey*

118	Articles published in the popular press	BOGAZICI	Kutsal Hazineye Koruma (Protection of cultural treasures)	23 December 2010	Sabah Metropo newspaper, Turkey	Civil Society		Turkey
119	Articles published in the popular press	BOGAZICI	Biri bizi hissediyor (Somebody is sensing us)	10 November 2012	Radikal newspaper, Turkey	Civil Society		Turkey
120	Articles published in the popular press	CNR	"Da Galceti al cuore dell'europa" ("From Galceti to the heart of Europe")	19 August 2010	Il Nuovo Corriere, Italy	Civil Society		Italy
121	Articles published in the popular press	CNR	"Progetto di tutela dei siti archeologici" ("Archeological sites protection project")	19 August 2010	Il Tirreno newspaper, Italy	Civil Society		Italy
122	Articles published in the popular press	CNR	"Al via la seconda fase del progetto Firesense" - ("The second phase of the Firesense project starts")	3 September 2010	Metropoli newspaper, Italy	Civil Society		Italy
123	Articles published in the popular press	CNR	"Galceti esempio contro i roghi" ("Galceti, an example against fires")	19 August 2010	La Nazione newspaper, Italy	Civil Society		Italy
124	Articles published in the popular press	CNR	"Il grande fratello che combatte gli incendi" ("The big brother fighting fires")	11 June 2011	La Nazione newspaper, Italy	Civil Society		Italy

125	*Articles published in the popular press*	*CNR*	*“Firesense: Il Centro di Scienze Naturali sara' area test del progetto” (Firesense: The Centre for Natural Science will host the project”)*	*11 June 2011*	*Metropoli newspaper, Italy*	*Civil Society*		*Italy*
126	*Articles published in the popular press*	*CNR*	*“Le telecamere scova-incendi” (“The camera able to detect fires”)*	*11 June 2011*	*Il Tirreno newspaper, Italy*	*Civil Society*		*Italy*
127	*Articles published in the popular press*	*CNR*	*“Care vecchie vedette addio” (“Dear old lookouts, Godbye!”)*	*11 June 2011*	*Il Nuovo Corriere newspaper, Italy*	*Civil Society*		*Italy*
128	*Press Release*	*CERTH*	*FIRESENSE project*	*10 October 2011*	*EU PARLIAMENT Magazine (Issue 335)*	*Scientific Community, Policy makers*		*Europe*
129	*Press Release*	*BOGAZICI*	*FIRESENSE yangin erken uyari sistemi başariyla test edildi (Firesense early fire warning system successfully tested in Bogazici)*	*October 2012*	*Bogazici Corporate Relations Directorate Buletin*	*Civil Society*		*Turkey*
130	*Press Release*	*BOGAZICI*	*Firesense Information Day in Dodge Hall*	*January 2013*	*Bogazici Corporate Relations Directorate Buletin*	*Civil Society*		*Turkey*
131	*Press release*	*HMC*	*Events for International Museum Day 2012*	*May 2012*	*Athens -Thebes, Greece*	*Scientific Community, Civil Society, Medias*		*Greece*
132	*Press release*	*HMC*	*Information Day and Open Demonstration of FIRESENSE*	*24 January 2013*	*Thebes, Greece*	*Scientific Community, Civil Society, Medias*		*Greece*

133	Press release	CNR	The FIRESENSE project will include Galceti Park as one of the test sites	17 August 2010	Prato, Italy	Medias	10	Italy
134	Press release	CNR	"The international panel of Firesense experts meet in Galceti Park"	10 June 2011	Prato, Italy	Medias	15	Italy
135	Media Briefing	CNR	Press conference about the FIRESENSE project	10 June 2011	Galceti Park, Prato, Italy	Medias	20	Italy
136	Media Briefing	SUPCOM	Media briefing about the FIRESENSE project and the prototype installed in the Temple of Water to the Tunisian Press Agency (TAP)	6 December 2012	Tunisia	Medias		Tunisia
137	Interview	CERTH	Multi-sensors fire shields, Interview of Nikos Grammalidis	13 February 2013	http://www.innovationseeds.eu	Medias		International
138	Interview	CERTH	Interview of Coordinator N. Grammalidis and Kosmas Dimitropoulos about FIRESENSE	23 June 2011	ET3 - Greek National TV Channel, Thessaloniki, Greece	Medias	10,000,000	Greece
139	Interview	HMC	Interview of V. Aravantinos about FIRESENSE	23 June 2011	ET3 - Greek National TV Channel, Thessaloniki, Greece	Medias	10,000,000	Greece
140	Interview	CERTH	Interview of Coordinator N. Grammalidis about FIRESENSE	7 September 2011	Heritage Portal (http://www.heritageportal.eu/)			Europe
141	Interview	BILKENT	Interview of Enis Cetin about FIRESENSE	6 September 2011	Heritage Portal (http://www.heritageportal.eu/)			Europe
142	Interview	CERTH	Interview of Coordinator N. Grammalidis about FIRESENSE	12 November 2010	CANAL PATRIMONIO, Valladolid, Spain	Medias		International

143	Interview	CERTH	Interview of Coordinator N. Grammalidis about FIRESENSE was released in news portals : - youris.com - phys.org	February 2013	Thessaloniki, Greece	Medias		Greece
144	Interview	CERTH	Interview of Kosmas Dimitropoulos about FIRESENSE The article was released in more than twenty Greek news sites: http://www.express.gr http://www.newsinnews.gr http://gr.newschrome.com http://www.inews.gr http://www.newsbeast.gr http://www.metrogreece.gr http://newpost.gr http://www.xrima-online.gr http://www.axiaplus.gr http://www.youmag.gr http://www.pentelikonews.gr	10 May 2011	Athens News Agency, Greece	Medias	10,000,000	Greece
145	Interview	SUPCOM	Interview of SUPCOM members about FIRESENSE	25 January 2013	“Kalima” Tunisian Radio	Medias		Tunisia
146	Interview	SUPCOM	Interview about FIRESENSE	25 January 2013	“Mosaiquefm” Tunisian Radio	Medias		Tunisia

147	Interview	BILKENT	Interview of Prof. Enis Cetin about FIRESENSE	4 February 2013	Anatolian News Agency, Turkey	Medias		Turkey
148	Interview	BILKENT	Interview of Prof. Enis Cetin about FIRESENSE	8 July 2011	TRT (Turkish Radio Television), Turkey	Civil Society		Turkey
149	Interview	HMC	Interview of V. Aravantinos about Firesense and the pilot site of Kabireion	10 June 2011	RAI channel, Prato, Italy	Medias		Italy
150	TV clip	BILKENT	Yangına Erken Mudahale (Early intervention to fire)	4 February 2013	Haberturk channel, Turkey	Civil Society		Turkey
151	TV clip	BILKENT	Yangını Erken algılayan cihaz (Device that detects fire early)	4 February 2013	Channel 7, Turkey	Civil Society		Turkey
152	TV clip	BILKENT	Creativeness/ innovation makes fire detector more effective	14 February 2013	CNTV Channel, China	Civil Society		China
153	TV clip	BILKENT	Orman yangınlarına karşı erken uyarı sistemi (Early warning system against wildfires)	5 July 2012	Channel 2, Turkey	Civil Society		Turkey
154	TV clip	BILKENT	Rhodiapolis	23 July 2011	NTV channel, Turkey	Civil Society		Turkey
155	TV clip	CNR	A new possibility in fire fighting: the Firesense system	3 June 2011	RAI3 regional TV news, Prato, Italy	Civil Society		Italy
156	TV clip	CNR	European project in Galceti Park will help in fire fighting: The Firesense system	10 June 2011	Prato TV, Prato, Italy	Civil Society		Italy
157	Video	SUPCOM	Firesense Project presentation by SUPCOM members	4 February 2013	YouTube http://www.youtube.com/watch?v=-DITN5_Qys0	Scientific Community, Civil Society		International

158	*Video*	*SUPCOM*	*Tutorial for FIRESENSE Control Center software*	*8 March 2003*	*YouTube* *http://www.youtube.com/watch?v=XtXDSEByvxA*	*Scientific Community, Civil Society*		*International*
159	*Video*	*BILKENT*	*Fire detection in Cirali, Turkey using FIRESENSE cameras*	*November 2012*	*FIRESENSE website*	*Scientific Community, Civil Society*		*International*
160	*Exhibition*	*CERTH*	*AR & PA Innovation 2010*	*11-14 November 2010*	*Valladolid, Spain*	*Civil Society*	*1,000*	*International*
161	*Exhibition*	*CERTH*	*Infosystem 2010*	*8-10 October 2010*	*Thessaloniki, Greece*	*Civil Society*	*300*	*Greece*
162	*Exhibition*	*CERTH*	*AR & PA Innovation 2010*	*24-27 May 2012*	*Valladolid, Spain*	*Civil Society*	*1,000*	*International*
163	*Exhibition*	*CERTH*	*4th International Euro-Mediterranean Conference on Cultural Heritage (EUROMED 2012)*	*29 October-3 November 2012*	*Lemesos, Cyprus*	*Scientific Community*	*500*	*International*
164	*Exhibition*	*CERTH*	*ITI-CERTH Open Day 2010*	*11 June 2010*	*Thessaloniki, Greece*	*Civil Society*	*100*	*Greece*
165	*Exhibition*	*CERTH*	*ITI-CERTH Open Day 2011*	*6 May 2011*	*Thessaloniki, Greece*	*Civil Society*	*100*	*Greece*
166	*Exhibition*	*BOGAZICI*	*ICT 2010 Conference*	*26-29 September 2010*	*Brussels, Belgium*	*Civil Society, Scientific Community, Medias*	*5,000*	*European*
167	*Fair*	*TITAN*	*FIRESENSE Project*	*13 December 2010*	*Patent Fair, İzmir, Turkey*	*Industry, Civil Society*	*1,000*	*Turkey*
168	*Workshop*	*BILKENT*	*FIRESENSE Workshop: International Workshop on Multi-Sensor Systems and Networks for Fire Detection and Management*	*8-9 November 2012*	*Antalya, Turkey*	*Scientific Community, Civil Society, Policy makers*	*50*	*International*

169	Workshop	BILKENT	Special session on "Signal processing for disaster management and prevention" on 19th European Signal Processing Conference (EUSIPCO-2011)	31 August 2011	Barcelona, Spain	Scientific Community	40	International
170	Workshop	BILKENT	Workshop on "Wireless Sensor Networks for Environment Sensing" in URSI 2011 Symposium	13 August 2011	Istanbul, Turkey	Scientific Community		International
171	Workshop	SUPCOM	EuroAfrica-ICT FP7 Awareness & Training workshop	October 9-10, 2012	Tunis, Tunisia	Scientific Community, Policy Makers, Medias, Industry	200	Tunisia
172	Workshop	CERTH	CERTH's Liaison Office event	15 December 2011	Thessaloniki, Greece	Industry	81 representatives from approximately 50 companies.	Greece
173	Workshop	CERTH	FIRESENSE clustering Event	9 December 2011	Thessaloniki, Greece	Scientific Community	20	Greece, Turkey, Italy, Tunisia, Belgium, The Netherlands
174	Workshop	CERTH	INTERVALUE project's Workshop.	25 May 2012	Thessaloniki, Greece	Industry	20	Greece

175	*Workshop*	*CERTH*	*Fire Paradox Conference: “Towards an Integrated Wild land Fire Management - Outcomes of the European Project Fire-Paradox*	*25-26 February 2010*	*Freiburg, Germany*	*Scientific Community, Industry, Policy Makers*		*Europe*
177	*Workshop*	*HMC*	*Information day for the FIRESENSE system in Kabeirion*	*24 January 2013*	*Thebes, Greece*	*Civil society, Scientific Community*	*40*	*Greece*
178	*Workshop*	*CNR*	*Meeting with stakeholders (cultural heritage authorities, fire department, civil protection authorities, forest department, local authorities, a*	*26 October 2012*	*Centre for Natural Science, Galceti Park, Prato, Italy*	*Civil society*	*15*	*Italy*
179	*Workshop*	*CNR*	*Lecture for inhabitants in Galceti Park*	*1 December 2012*	*Galceti Park, Prato, Italy*	*Civil society*	*15*	*Italy*
180	*Presentation*	*CERTH*	*Lecture on "Flame detection and fire propagation estimation”, CERTH Seminars*	*5 October 2011*	*Thessaloniki, Greece*	*Scientific Community*	*25*	*Greece*
181	*Presentation*	*CERTH*	*Presentation of FIRESENSE project in the Forest Research Institute of Athens*	*26 February 2013*	*Athens, Greece*	*Scientific Community*	*10*	*Greece*
182	*Presentation*	*BILKENT*	*Bilgisayarlı Görmeye Dayalı Orman Yangını Bulma ve İzleme Sistemi (Computer-Based Forest Fire Detection and Monitoring System)*	*13 September 2012*	*Antalya*	*Industry*	*30*	*Turkey*
183	*Presentation*	*BILKENT*	*Rhodiapolis*	*2011*	*Kumluca Vefa Hill High School, Antalya, Turkey*	*Civil Society*	*30*	*Turkey*
184	*Presentation*	*BILKENT*	*Rhodiapolis*	*2012*	*Kumluca Vefa Hill High School, Antalya, Turkey*	*Civil Society*	*30*	*Turkey*

185	Presentation	BILKENT	FIRESENSE Project	2012	University of Illinois, Chicago, US	Scientific Community		US
186	Presentation	BILKENT	Wildfire Detection in video	2010	Stony Brook University, US	Scientific Community		US
187	Presentation	BILKENT	Wildfire Detection in video	2010	Ohio State University, US	Scientific Community		US
188	Presentation	SUPCOM	FIRESENSE project presentation for Sup'Com undergraduate students	31 January 2013	Ecole Supérieure des Communications de Tunis (Sup'Com), Tunis, Tunisia	Scientific Community (Higher education)	80	Tunisia
189	Presentation	XENICS	Presentation for Fabricom	July 2012	Aartselaar, Belgium	Industry	5	Europe
190	Presentation	XENICS	Presentation for Siemens	May 2011	Brussels, Belgium	Industry	10	Europe
191	Presentation	XENICS	Presentation for unisys	November 2012	Brussels, Belgium	Industry	5	Belgium
192	Presentation	XENICS	True image sensor fusion applied to wildfire detection	October 2011	NASA SensorTech Symposium, in Boston, US	Industry, Scientific Community		International
193	Presentation	HMC	New Technologies at the Service of the Cultural Inheritance	17 May 2012, International Museum Day 2012	Thebes, Greece	Scientific Community, Civil Society	70	Greece
194	Presentation	CNR	Technical meeting on post-fire hazards	6 November 2012	Perugia - Regione Umbria –Department of Civil Protection, Italy	Other		Italy
196	Presentation	CNR	FIRESENSE project & technologies	1 December 2012	Galceti Park, Prato, Italy	Civil Society	15	Italy
197	Presentation	CNR	Effect of fires on soil and idrogeological disasters	1 December 2012	Galceti Park, Prato, Italy	Civil Society	15	Italy

198	Presentation	CNR	What to do in case of fire or if a fire is observed	1 December 2012	Galceti Park, Prato, Italy	Civil Society	15	Italy
199	Presentation	CNR	FIRESENSE project & technologies	26 October 2012	Galceti Park, Prato, Italy	Civil Society	15	Italy
200	Poster	CERTH	FIRESENSE Project, FIRESENSE technologies, FIRESENSE puzzle		AR&PA 2010, Valladolid, Spain AR&PA 2012, Valladolid, Spain EuroMed 2012, Lemesos, Cyprus	Civil Society	1,500	International
201	Poster	CERTH	Video based flame detection using spatio-temporal features and SVM classification	24-26 February 2012	International Conference on Computer Vision Theory and Applications (VISAPP2012), Rome, Italy,	Scientific Community	200	International
202	Poster	HMC	FIRESENSE project at the pilot site of the Sanctuary of Kabireion, Thebes	15-18 March 2012	4th Archaeological Meeting of Thessaly and Central Greece (AETHSE), Volos, Greece	Scientific Community	100	Greece
203	Thesis	BOGAZICI	Load Balanced Forwarding in Multimedia Wireless Sensor Networks, PhD thesis, Sinan Isik	20 January 2011	Bogazici University, Computer Engineering Department, Istanbul, Turkey	Scientific Community		Turkey
204	Thesis	BOGAZICI	Quality of Service Aware Contention and Deployment Quality Analysis In Wireless Sensor Networks, Networks, PhD thesis, Yunus Donmez	27 January 2011	Bogazici University, Computer Engineering Department, Istanbul, Turkey	Scientific Community		Turkey
205	Thesis	BOGAZICI	Fuzzy Logic Based Congestion Control for Progressive Image Transmission over Wireless Sensor Networks, MSc thesis, Çağatay Sönmez	29 May 2012	Bogazici University, Computer Engineering Department, Istanbul, Turkey	Scientific Community		Turkey

206	Thesis	BOGAZICI	Energy-Efficient Routing for Wireless Sensor Networks with a Mobile Sink, MSc thesis Can Tunca	6 September 2012	Bogazici University, Computer Engineering Department, Istanbul, Turkey	Scientific Community		Turkey
207	Other	BILKENT	Demonstration in ICPR 2010	28 August 2010	Istanbul, Turkey	Scientific Community	200	International
208	Other	BILKENT	Demonstration to Microsens	2013	Ankara, Turkey	Industry		Turkey
209	Other	BILKENT	Demonstration to BDY	31 January 2013	Ankara, Turkey	Industry		Turkey
210	Other	BILKENT	Demonstration to FlatDis	January 2013	Ankara, Turkey	Industry		Korea
211	Other	BILKENT	Demonstration to OGDTEK	January 2013	Ankara, Turkey	Industry		Turkey
212	Other	BILKENT	Demonstration to MilSOFT	2011	Ankara, Turkey	Industry		Turkey
213	Other	SUPCOM	Firesense system demonstration at the Temple of Water	2 November 2012	Zaghouan, Tunisia	Scientific Community, Civil Society, Policy makers, Other	20	Tunisia
214	Other	SUPCOM	Firesense system demonstration at the Temple of Water	25 January 2013	Zaghouan, Tunisia	Scientific Community, Civil Society, Policy makers, Other	28	Tunisia
215	Other	CNR	Firesense system demonstration in Galceti Park	26 October 2012	Galceti Park, Prato, Italy	Scientific Community, Civil Society, Policy makers, Other	15	Italy

216	*Other*	*BOGAZICI*	*Firesense system demonstration in Dodge Hall*	*6 December 2012*	*Dodge Hall, Bogazici University, Istanbul, Turkey*	*Scientific Community, Civil Society, Other*		*Turkey*
217	*Other*	*BOGAZICI*	*Firesense Car Park Fire Test*	*20 September 2012*	*Bogazici University, Istanbul, Turkey*	*Civil Society, Scientific Community, Medias*	*30+*	*International*
218	*Other*	*SUPCOM*	*One day seminar: ICT & Environment*	*6 December 2012*	*Elghazela Technoparc-Tunis, Tunisa*	*Scientific Community*	*80*	*Tunisia*
219	*Other*	*BOGAZICI*	*Seminar about the FIRESENSE project*	*13 December 2011*	*Bogazici University, Computer Engineering Department, Istanbul, Turkey*	*Scientific Community, Students*		*Turkey*
220	*Other*	*HMC*	*Lecture of V. Aravantinos about the Sanctuary of Kabireion and its importance*	*October 2010*	*Thebes, Greece*	*Scientific Community, Civil Society*	*30*	*Greece*
221	*Other*	*HMC*	*Lecture of A Harami about the importance of the Sanctuary of Kabireion for the development of the city of Thebes*	*24 June 2012*	*Cultural association "Laios", Thebes, Greece*	*Scientific Community, Civil Society*	*40*	*Greece*
222	*Other*	*HMC*	*Lecture of A Harami about the Sanctuary of Kabireion*	*24 January 2013*	*Thebes, Greece*	*Scientific Community, Civil Society*	*40*	*Greece*
223	*Other*	*HMC*	*Guided archaeological tour in Kabeirion*	*October 2010*	*Thebes, Greece*	*Scientific Community, Civil Society*	*20*	*Greece*
224	*Other*	*HMC*	*Guided archaeological tour in Kabeirion*	*April 2012*	*Thebes, Greece*	*Civil Society*	*30*	*Greece*
225	*Other*	*HMC*	*Guided archaeological tour in Kabeirion*	*24 June 2012*	*Thebes, Greece*	*Scientific Community, Civil Society*	*30*	*Greece*

226	Other	HMC	Educational programme for school classes about the Sanctuary of Kabireion	15 May 2012	Thebes, Greece	Civil Society	35	Greece
227	Other	HMC	Educational programme for school classes about the Sanctuary of Kabireion	18 May 2012	Thebes, Greece	Civil Society	40	Greece
228	Other	HMC	Open weekend educational programme for families focusing on the Sanctuary of Kabireion	21 May 2012	Thebes, Greece	Civil Society	45	Greece
229	Other	HMC	Open weekend educational programme for families focusing on the Sanctuary of Kabireion	21 October 2012	Thebes, Greece	Civil Society	50	Greece
230	Presentation	TITAN	FIRESENSE Project	10.08.2010	Ankara, Turkey	Industry	15	Turkey
231	Presentation	TITAN	FIRESENSE Project	18.08.2010	Ankara, Turkey	Industry	15	Turkey
232	Presentation	TITAN	FIRESENSE Project	24.12.2010	Istanbul, Turkey	Industry	15	Turkey
233	Presentation	TITAN	FIRESENSE Project	08.12.2010	Malatya, Turkey	Industry	30	Turkey
243	Presentation	TITAN	FIRESENSE Project	23.12.2010	Erzurum, Turkey	Industry	30	Turkey
235	Presentation	TITAN	FIRESENSE Project	02.12.2010	Nakhchivan, Azerbaijan	Industry	40	Azerbeijan
236	Presentation	TITAN	FIRESENSE Project	07.12.2010	Paris, France	Industry	40	France
238	Presentation	TITAN	FIRESENSE Project	26.07.2010	Ankara, Turkey	Industry	15	Turkey
239	Demo	TITAN	FIRESENSE Project	05.07.2010	Nicosia, Cryprus	Industry	40	Cyprus
240	Demo + Presentation	TITAN	FIRESENSE Project	11.07.2010	Malatya, Turkey	Industry	30	Turkey
241	Demo	TITAN	FIRESENSE Project	25.07.2010	Nicosia, Cryprus	Industry	30	Cyprus
242	Presentation	TITAN	FIRESENSE Project	21.06.2010	Ankara, Turkey	Industry	15	Turkey
243	Demo	TITAN		09.06.2010	Nicosia, Cryprus	Industry	30	Cyprus

244	Presentation	TITAN	FIRESENSE Project	16.11.2010	Izmir, Turkey	Industry	30	Turkey
245	Presentation	TITAN	FIRESENSE Project	23.11.2010	Adana, Turkey	Industry	20	Turkey
246	Presentation	TITAN	FIRESENSE Project	18.10.2010	Ankara, Turkey	Industry	15	Turkey
247	Presentation	TITAN	FIRESENSE Project	03.10.2010	Elazig, Turkey	Industry	40	Turkey
248	Presentation	TITAN	FIRESENSE Project	08.10.2010	Erzurum, Turkey	Industry	35	Turkey
249	Presentation	TITAN	FIRESENSE Project	23.09.2010	Ankara, Turkey	Industry	15	Turkey
250	Presentation	TITAN	FIRESENSE Project	27.10.2010	Kalecik, Turkey	Industry	15	Turkey
251	Presentation	TITAN	FIRESENSE Project	10.09.2010	Malatya, Turkey	Industry	20	Turkey
252	Presentation	TITAN	FIRESENSE Project	16.09.2010	Nicosia, Cyprus	Industry	20	Cyprus
253	Presentation	TITAN	FIRESENSE Project	25.02.2011	Iskenderun, Turkey	Industry	30	Turkey
254	Presentation	TITAN	FIRESENSE Project	09.02.2011	Vienna, Austria	Industry	20	Austria
255	Presentation	TITAN	FIRESENSE Project	17.02.2011	Austin, TX, USA	Industry	20	USA
256	Presentation	TITAN	FIRESENSE Project	12.01.2011	Adana, Turkey	Industry	20	Turkey
257	Presentation	TITAN	FIRESENSE Project	25.01.2011	Hatay, Turkey	Industry	20	Turkey
258	Presentation	TITAN	FIRESENSE Project	06.01.2011	Tripoli, Libya	Industry	30	Libya
259	Presentation	TITAN	FIRESENSE Project	14.01.2011	Izmir, Turkey	Industry	30	Turkey
260	Presentation	TITAN	FIRESENSE Project	01.03.2011	Ankara, Turkey	Industry	15	Turkey
261	Presentation	TITAN	FIRESENSE Project	14.03.2011	Ankara, Turkey	Industry	15	Turkey
262	Presentation	TITAN	FIRESENSE Project	23.03.2011	Ankara, Turkey	Industry	15	Turkey
263	Presentation	TITAN	FIRESENSE Project	04.04.2011	Ankara, Turkey	Industry	15	Turkey
264	Presentation	TITAN	FIRESENSE Project	13.04.2011	Istanbul, Turkey	Industry	15	Turkey
265	Presentation	TITAN	FIRESENSE Project	14.04.2011	Istanbul, Turkey	Industry	20	Turkey
266	Presentation	TITAN	FIRESENSE Project	25.04.2011	Ankara, Turkey	Industry	15	Turkey
267	Presentation	TITAN	FIRESENSE Project	09.05.2011	Ankara, Turkey	Industry	15	Turkey
268	Presentation	TITAN	FIRESENSE Project	16.05.2011	Ankara, Turkey	Industry	15	Turkey
269	Presentation	TITAN	FIRESENSE Project	20.05.2011	Antalya Turkey	Industry	20	Turkey

270	Presentation	TITAN	FIRESENSE Project	30.05.2011	Ankara, Turkey	Industry	15	Turkey
271	Presentation	TITAN	FIRESENSE Project	01.06.2011	Ankara, Turkey	Industry	15	Turkey
272	Presentation	TITAN	FIRESENSE Project	06.06.2011	Ankara, Turkey	Industry	15	Turkey
273	Presentation	TITAN	FIRESENSE Project	07.06.2011	Istanbul Turkey	Industry	20	Turkey
274	Presentation	TITAN	FIRESENSE Project	15.06.2011	Baku, Azerbaijan	Industry	30	Azerbaijan
275	Presentation	TITAN	FIRESENSE Project	17.06.2011	Ankara, Turkey	Industry	15	Turkey
276	Presentation	TITAN	FIRESENSE Project	27.06.2011	Ankara, Turkey	Industry	15	Turkey
277	Presentation	TITAN	FIRESENSE Project	05.07.2011	Ankara, Turkey	Industry	15	Turkey
278	Presentation	TITAN	FIRESENSE Project	11.07.2011	Ankara, Turkey	Industry	15	Turkey
279	Presentation	TITAN	FIRESENSE Project	12.07.2011	Samsun Turkey	Industry	20	Turkey
280	Presentation	TITAN	FIRESENSE Project	13.07.2011	Ankara, Turkey	Industry	15	Turkey
281	Presentation	TITAN	FIRESENSE Project	18.07.2011	Ankara, Turkey	Industry	15	Turkey
282	Presentation	TITAN	FIRESENSE Project	02.08.2011	Ankara, Turkey	Industry	15	Turkey
283	Presentation	TITAN	FIRESENSE Project	16.08.2011	Ankara, Turkey	Industry	15	Turkey
284	Presentation	TITAN	FIRESENSE Project	22.08.2011	Istanbul, Turkey	Industry	20	Turkey
285	Presentation	TITAN	FIRESENSE Project	25.08.2011	Ankara, Turkey	Industry	15	Turkey
286	Presentation	TITAN	FIRESENSE Project	07.09.2011	Ankara, Turkey	Industry	15	Turkey
287	Presentation	TITAN	FIRESENSE Project	12.09.2011	Tashkent, Uzbekistan	Industry	15	Uzbekistan
288	Presentation	TITAN	FIRESENSE Project	15.09.2011	Ankara, Turkey	Industry	20	Turkey
289	Presentation	TITAN	FIRESENSE Project	10.10.2011	Ankara, Turkey	Industry	15	Turkey
290	Presentation	TITAN	FIRESENSE Project	19.10.2011	Didim, Turkey	Industry	20	Turkey
291	Presentation	TITAN	FIRESENSE Project	21.10.2011	Ankara, Turkey	Industry	15	Turkey
292	Presentation	TITAN	FIRESENSE Project	21.11.2011	Ankara, Turkey	Industry	15	Turkey
293	Presentation	TITAN	FIRESENSE Project	30.11.2011	Ankara, Turkey	Industry	15	Turkey
294	Presentation	TITAN	FIRESENSE Project	01.12.2011	Ankara, Turkey	Industry	15	Turkey
295	Presentation	TITAN	FIRESENSE Project	07.12.2011	Mecca, Saudi Arabia	Industry	50	Saudi Arabia

296	Presentation	TITAN	FIRESENSE Project	15.12.2011	Ankara, Turkey	Industry	15	Turkey
297	Presentation	TITAN	FIRESENSE Project	17.12.2011	Ankara, Turkey	Industry	15	Turkey
298	Presentation	TITAN	FIRESENSE Project	09.01.2012	Istanbul, Turkey	Industry	15	Turkey
299	Presentation	TITAN	FIRESENSE Project	16.01.2012	Ankara, Turkey	Industry	15	Turkey
300	Presentation	TITAN	FIRESENSE Project	19.01.2012	Ankara, Turkey	Industry	15	Turkey
301	Presentation	TITAN	PIR based Fire Detection	20.01.2012	Antalya, Turkey	Industry	40	Turkey
302	Presentation	TITAN	FIRESENSE Project	24.01.2012	Ankara, Turkey	Industry	15	Turkey
303	Presentation	TITAN	FIRESENSE Project	13.02.2012	Munich, Germany	Industry	50	Germany
304	Presentation	TITAN	FIRESENSE Project	19.02.2012	Ankara, Turkey	Industry	15	Turkey
305	Presentation	TITAN	FIRESENSE Project	28.02.2012	Ankara, Turkey	Industry	15	Turkey
306	Presentation	TITAN	FIRESENSE Project	07.03.2012	Ankara, Turkey	Industry	15	Turkey
307	Presentation	TITAN	FIRESENSE Project	27.03.2012	Ankara, Turkey	Industry	15	Turkey
308	Presentation	TITAN	FIRESENSE Project	29.03.2012	Sochi, Russia	Industry	30	Russia
309	Presentation	TITAN	FIRESENSE Project	04.04.2012	Ankara, Turkey	Industry	15	Turkey
310	Presentation	TITAN	FIRESENSE Project	16.04.2012	Ankara, Turkey	Industry	15	Turkey
311	Presentation	TITAN	FIRESENSE Project	26.04.2012	Ankara, Turkey	Industry	15	Turkey
312	Presentation	TITAN	FIRESENSE Project	10.05.2012	Ankara, Turkey	Industry	15	Turkey
313	Presentation	TITAN	FIRESENSE Project	20.05.2012	Istanbul, Turkey	Industry	15	Turkey
314	Presentation	TITAN	FIRESENSE Project	26.06.2012	Ankara, Turkey	Industry	15	Turkey
315	Presentation	TITAN	FIRESENSE Project	16.07.2012	Ankara, Turkey	Industry	15	Turkey
316	Presentation	TITAN	FIRESENSE Project	13.08.2012	Ankara, Turkey	Industry	15	Turkey
317	Presentation	TITAN	Fire Panel Integration	20.08.2012	Ankara, Turkey	Scientific Community	10	Turkey
318	Presentation	TITAN	FIRESENSE Project	03.09.2012	Ankara, Turkey	Industry	15	Turkey
319	Presentation	TITAN	FIRESENSE Project	11.09.2012	Astana, Kazakhstan	Industry	25	Kazakhstan
320	Presentation	TITAN	FIRESENSE Project	24.09.2012	Ankara, Turkey	Industry	15	Turkey

321	Presentation	TITAN	FIRESENSE Project	04.10.2012	Ankara, Turkey	Industry	15	Turkey
322	Presentation	TITAN	FIRESENSE Project	10.10.2012	Ankara, Turkey	Industry	15	Turkey
323	Presentation	TITAN	FIRESENSE Project	12.11.2012	Ankara, Turkey	Industry	15	Turkey
324	Presentation	TITAN	PIR based Fire detection	14.11.2012	Çankaya University, Ankara Turkey	Scientific Community	40	Turkey
325	Presentation	TITAN	FIRESENSE Project	16.11.2012	Ankara, Turkey	Industry	15	Turkey
326	Presentation	TITAN	FIRESENSE Project	21.11.2012	Urgench, Uzbekistan	Industry	25	Uzbekistan
327	Presentation	TITAN	FIRESENSE Project	04.12.2012	Ankara, Turkey	Industry	15	Turkey
328	Presentation	TITAN	FIRESENSE Project	07.12.2012	Ankara, Turkey	Industry	15	Turkey
329	Presentation	TITAN	FIRESENSE Project	17.12.2012	Ankara, Turkey	Industry	15	Turkey
330	Presentation	TITAN	FIRESENSE Project	07.01.2013	Ankara, Turkey	Industry	15	Turkey
341	Presentation	TITAN	PIR based Fire Detection	11.01.2012	Antalya, Turkey	Industry	40	Turkey
342	Presentation	TITAN	Infrared Fire Detection System	18.01.2013	Ankara, Turkey	Industry	15	Turkey
343	Presentation	TITAN	FIRESENSE Project	18.01.2013	Ankara, Turkey	Industry	15	Turkey
344	Presentation	TITAN	FIRESENSE Project	23.01.2013	Ankara, Turkey	Industry	15	Turkey
345	Presentation	TITAN	FIRESENSE Project	06.02.2013	Ankara, Turkey	Industry	15	Turkey
346	Presentation	TITAN	FIRESENSE Project	18.02.2013	Ankara, Turkey	Industry	15	Turkey

Section B (Confidential[6] or public: confidential information to be marked clearly)
Part B1

The applications for patents, trademarks, registered designs, etc. shall be listed according to the template B1 provided hereafter.

The list should, specify at least one unique identifier e.g. European Patent application reference. For patent applications, only if applicable, contributions to standards should be specified. This table is cumulative, which means that it should always show all applications from the beginning until after the end of the project.

TEMPLATE B1: LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, ETC.					
Type of IP Rights[7]:	**Confidential Click on YES/NO**	**Foreseen embargo date dd/mm/yyyy**	**Application reference(s) (e.g. EP123456)**	**Subject or title of application**	**Applicant (s) (as on the application)**
Patent	No	02/02/2014	2012/12602	Method and System for Fire Detection Using Differential Passive Infrared (PIR) Sensor	Ahmet Enis Cetin, Fatih Erden, and Behcet Ugur Toreyin
Patent	No	17/04/2012	PCT/US2011/021486	Improved Method and System for Smoke Detection Using Nonlinear Analysis of Video	Delacom Detection Systems, LLC (for all designated States except US), Ahmet Enis Cetin (for US Only)

[6] Note to be confused with the "EU CONFIDENTIAL" classification for some security research projects.

[7] A drop down list allows choosing the type of IP rights: Patents, Trademarks, Registered designs, Utility models, Others.

Part B2
Please complete the table hereafter:

Type of Exploitable Foreground[8]	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application[9]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
Commercial exploitation of R&D results	*Algorithms for fire and smoke detection based on video cameras. These algorithms include: a) covariance matrix based fire detection, b) color probability, spatial wavelet energy, temporal energy, spatiotemporal variance and contour (flickering) based fire detection, c) adaptive background with persistent pixels (ABPP) based fire detection, d) covariance matrix based smoke detection, e) entropy functional based online adaptive decision fusion based smoke detection*	*No*	*N/A*	*Fire and smoke detection (FSD) module based on video cameras (and plugins)*	*A2.4: support services to forestry C26.7: Manufacture of optical instruments and photographic equipment C28.3.0: Manufacture of agricultural and forestry machinery J62.0: Computer programming , consultancy and related activities N80.2: Security systems service activities M72.1: Research and*			*BILKENT (owner)* *Plugins by BILKENT, CERTH and SUPCOM*

[19] A drop down list allows choosing the type of foreground: General advancement of knowledge, Commercial exploitation of R&D results, Exploitation of R&D results via standards, exploitation of results through EU policies, exploitation of results through (social) innovation.
[9] A drop down list allows choosing the type sector (NACE nomenclature) : http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

Type of Exploitable Foreground[8]	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application[9]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
					experimental development on natural sciences and engineering			
Commercial exploitation of R&D results	*Algorithms for fire and smoke detection based on IR cameras. These algorithms include: a) fire detection with thermography and image fusion, b) BiModal (LWIR and visible) image processing for early fire detection, c) covariance features based IR video flame detection, d)silhouette based LWIR-visual smoke detection*	*No*	*N/A*	*Fire and smoke detection (FSD) module based on infrared (IR) cameras (and plugins)*	*A2.4: Support services to forestry N80.2: Security systems service activities M72.1: Research and experimental development on natural sciences and engineering*			*BILKENT (owner)* *Plugins by XENICS*
Commercial exploitation of R&D results	*Realisation of robust multi-camera / multiband vision solutions for (forest) fire detection. Three different realisations are earmarked:* *1) A single wavelength SWIR or LWIR camera for fire detection,* *2) a PTZ (pan, tilt and zoom) camera with visible channel*	*No*	*N/A*	*Multi-camera IR vision systems including embedded software and host software*	*A2.4: support services to forestry C26.7: Manufacture of optical instruments and photographic equipment C28.3.0: Manufacture of agricultural and forestry*	*Q3/2013 onwards*	*Confidentiality*	*Xenics (owner) + Firesense project partners*

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	for increased situational awareness and long detection range capability, and 3) a 3-band fusion camera containing visible, SWIR and uncooled LWIR systems for research purposes and increased detection performance				*machinery J62.0: Computer programming, consultancy and related activities M72.1.9: Other research and experimental development on natural sciences and engineering*			
Commercial exploitation of R&D results	*HMM-based flame detection algorithm based on PIR sensors*	*No*	*N/A*	*Flame detection module based on PIR sensors*	*C27.5.1: Manufacture of electric domestic appliances N80.2: Security systems service activities*		*Ahmet Enis Cetin, Fatih Erden, Behcet Ugur Toreyin, "Method and System for Fire Detection Using Differential Passive Infrared (PIR) Sensor", Turkish Patent Institute, Filing Date: February 2012.*	*BILKENT*
Commercial exploitation of R&D results	*The Wireless Sensor Network (WSN) that has been developed within Firesense comprises a clustered*	*No*	*N/A*	*WSN system (Wireless Sensor platform for outdoor deployments)*	*A2.4: Support services to forestry J61.2: Wireless telecommunications*			*CERTH (owner)*

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	hierarchical network for remote deployments in harsh environments. The network is deployed in sensor clusters of up to 20 members that can observe a small area (~ 1 acre of land). Each family has a clusterhead that communicates with all members with short range, low power radio. The clusterheads feature a long range radio (WiFi) and they contact the aggregation point of the deployment to deliver the sensor data.				*activities M72.1: Research and experimental development on natural sciences and engineering*			
General advancement of knowledge	*New method for finding salient deviations in noisy, clustered data streams from WSNs*	*No*	*N/A*	*Software for WSN alerts*	*A2.4: Support services to forestry M72.1: Research and experimental development on natural sciences and engineering*	*2015*	*-*	*Eric J. Pauwels, CWI*
Commercial	*The Control Center*	*No*	*N/A*	*Control centre*	*A2.4:*	*N/A*		*SUPCOM*

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exploitation of R&D results	*(CC) developed within Firesense allows the user to remotely monitor and control cultural heritage sites. The supervision of the system is performed through an interactive graphical user interface unit. The interface is comprised of three screens, in addition to a server, to ensure comfortable system monitoring: the main screen, the video screen and the maintenance screen. The CC/GUI is developed as a standalone application.*			*for monitoring cultural heritage or forested areas form the risk of fire*	*Support services to forestry N80.2: Security systems service activities R91.0.3: Operation of historical sites and buildings and similar visitor attractions*			*(owner)*
Commercial exploitation of R&D results	*The vegetation classification technique that has been developed within Firesense is based on Support Vector Machines (SVM) algorithm. The proposed technique introduces the spectral information through the NDVI*	*No*	*N/A*	*Vegetation maps*	*A2.4: Support services to forestry M72.1: Research and experimental development on natural sciences and engineering*	*N/A*		*SUPCOM (owner)*

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	index, the texture discriminating features by using Gabor wavelet decomposition and the spatial interaction within each channel by considering the ground spectral responses according to the different spectral bands. A low-pass filter based pansharpening is applied as a pre-processing step. Then, these features, merged into a feature vector, are used as input to SVM. The algorithm classifies each image pixel in predefined vegetations classes (e.g. based on CORINE nomenclature) and produces a vegetation map of the area.							
Commercial exploitation of R&D results	*The EFP software is a user-friendly GIS simulator, which provides 2D/3D*	*No*	*N/A*	*Estimation of Fire Propagation (and*	*A2.4: Support services to forestry*			*CERTH (plugin by BOGAZICI/CERTH)*

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	visualization of fire propagation estimation output (ignition time, flame length, crown fire probability) and enables interactive selection of parameters (e.g. ignition point, humidity parameters, wind direction etc). An extension (plugin), developed by CERTH and BOGAZICI, calculates temperatures from the output data of fire simulation, given specific heat propagation models.			*temperature estimation plugin)*	*M72.1: Research and experimental development on natural sciences and engineering*			
	The FIRESENSE system is an automatic early warning system integrating multiple sensors to remotely monitor areas of archaeological and cultural interest for the risk of fire and extreme weather conditions. The main components of the FIRESENSE	*No*	*N/A*	*FIRESENSE system*	*A2.4: Support services to forestry C27.9: Manufacture of other electrical equipment J61.2: Wireless telecommunications activities M72.1:*			*CERTH and all other FIRESENSE partners*

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	system are the Control Center and the Data Fusion module. A third important module, necessary if optical or IR cameras are to be connected is the Fire/Smoke/IR Detector (FSD). A Wireless sensor network (WSN) of temperature and humidity sensors can also be directly connected with the Data Fusion module. Finally, data from local weather stations on the deployment sites can also be supported.				*Research and experimental development on natural sciences and engineering N80.2: Security systems service activities R91.0.3: Operation of historical sites and buildings and similar visitor attractions*			