SEVENTH FRAMEWORK PROGRAMME

FP7-ICT-2011-1.5 Networked Media and Search Systems
b) End-to-end Immersive and Interactive Media Technologies

Specific Targeted Research Project

VENTURI

(FP7-288238)

immersiVe ENhancemenT of User-woRld Interactions

Public final activity report

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Contents

1. Executive Summary

1.1. Scope

This document provides a high-level review of the activities that VENTURI has carried out between October 2011 and September 2014, i.e. the entire span of the project

1.2. Audience

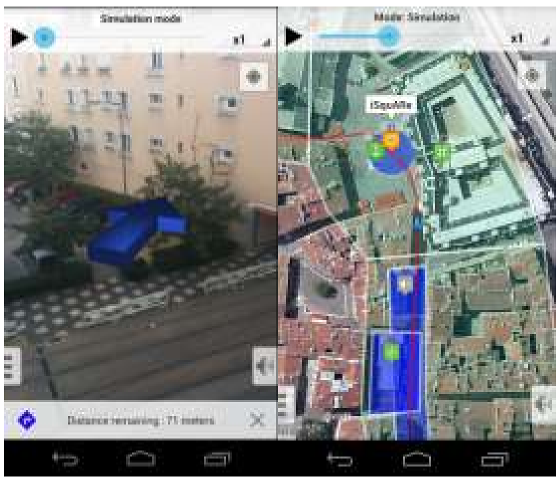
This deliverable is public.

1.3. Project Summary

VENTURI was a 36 month, Information and Communication Technologies\Collaborative, project that aimed to empower users with new Augmented Reality experiences by creating innovative technologies/services based on intelligent, adaptable and personalised delivery. By seamlessly injecting content into a user's world (i.e. their immediate surroundings) in an intuitive manner, we have been able to enhance a user's consumptions of multimedia content, making access to it a pleasure rather than a chore.

Augmented Reality 3 years ago was a very different experience from what we see now. VENTURI has focused of the exploitation of the visual sensing technologies of mobile devices and it attempted to go beyond the simple overlaying of 3D virtual reality objects into the scene. VENTURI has created a more immersive experience supported by AR interaction user-studies, actual and social context awareness, 3D visual analysis of the surroundings. The outcomes from the project demonstrate that users can now actively engage with different types of mobile content (both audio and visual), create new ones with 3D creation tools and share personal content with others. We believe that we have surpassed our original goal of providing an increased QoE for the mixed reality delivery by exploring a wide variety of AR domains and scenarios and by trying to make interactions as natural as possible through the use of new wearable device that were not foreseen 3 years ago.

By successfully bringing together the fields of social networking, signal processing, computer vision, graphics and augmented reality, combined with the know-how and product/services design capability of a Mobile Computing Platform architects and designers, Internet and mobile media production, we have managed to create algorithms and proof of concept demonstrators that encompass the whole value chain in the networked media sector.



To provide a clear picture of the capabilities of VENTURI and give some solid means of system validation, three consolidated prototypes each depicting a typical AR scenario were created during the project. These three technology demonstrators represented an indoor table top AR game, an indoor navigation assistant for the visually impaired and an outdoor AR City tour.

2. Overview of project context and objectives

The project focused on a series of technological research objectives that were directly related to state of the art research, market status and the predicted demands on AR technology by the end of the project. Associated to each of the objectives listed below, is the technical work package in which the research took place:

1. Enable developers and mobile device OEMs to create immersive and interactive environments by means of a mobile AR Platform adapted to the users' devices, based on the definition of an innovative SW/System architecture which is centred upon the current next generation state-of-the-art platform for Smartphones and Mobile Devices (lead WP2);
2. Create a new paradigm for prosumer-friendly, immersive and multimodal media representation aiming at a mix of real and virtual worlds with improved interaction capabilities which explores new sensing interfaces (lead WP3);
3. Exploit available sensor information to provide a comprehensive sensing of the user's context (on the move, at home and at work) from multiple points of view (lead WP4);
4. Create high quality 3D content and enable an efficient distribution of immersive media over the Internet, relevant and adapted to the determined user's context (lead WP5);
5. Evaluate and optimize Quality of Experience for the end user by improving the exploitation of mobile platform resources used by AR applications (lead WP6).

A unified approach across core imaging/graphics technologies, embedded mobile platforms and man-machine interfaces were instrumental to the success of VENTURI. Technical challenges, such as advanced real-time image recognition, high speed networking, content extraction/generation, massive multimedia processing and extensions/improvements of Platform SW/System structure were integrated to ensure an enhanced mobile user experience. The integrated architecture design illustrated an optimal trade-off between device usage, e.g. battery duration, and AR QoE performance. Powered by an increased level of context awareness and improved interaction capabilities, VENTURI was shown to provide an End-2-End immersive technology for the delivery of AR content to the user.

3. Description of the main S&T results/foregrounds

In this section we describe the main S&T outcomes of the various Workpackages and how the WPs interlinked successfully.

3.1. Workpackage 2: Architecture definition and development

The objectives of WP2 were: Use-case identification, System requirements analysis and to provide the backbone of the SW/HW infrastructure to be used throughout the project. However, due to the withdrawal of ST-E/ST-F two-thirds way through the project, not all of the hardware development objectives could be accomplished, even though some progress was made. The most important hardware developments to mention were: the basic development and delivery of the U9540 platform, the synchronization of IMU and camera image timestamps, the integration and testing of the Hillcrest Labs Library for enhanced motion estimation and the collection of camera statistics, which were later used to support scene classification algorithms. All other objectives were successfully accomplished, potential use cases were identified and described, and the HMD-enabled AR framework (developed in this work package) has become the backbone of large parts of the demonstration platforms implemented within VENTURI.

The major achievement of WP2 was the development of a versatile AR framework for mobile and desktop devices, including a tool chain facilitating several important use cases, such as 3D tracking of a previously unknown environment. This framework has been delivered as a standalone SDK package for usage by project partners, enabling them to create platform-dependent AR apps as well as platform-independent apps using the AREL language. The Metaio SDK is also the backbone of the Junaio platform, which allows the user to define AR scenarios via so-called 'channels' in a platform-independent way, and enables the user to connect their AR experiences to the web.

FIGURE 1: METAIO TOOLBOX, SHOWING 3D TRACKING IN ACTION.

FIGURE 2: FIRST-YEAR VENTURI DEMO AS PRESENTED AT MOBILE WORLD CONGRESS 2013, USING METAIO'S SDK IS PERFORMING 3D TRACKING AND RENDERING.

The only aspect that we think could have been done better in this WP concerns the optimization of our software modules. If we had had more time and resources, it would have been beneficial to have continued our paralleliza-tion efforts all the way through to the end of the project.

The most exploitable outcome of WP2 is HMD support which is now provided through metaio's SDK and the HMD browser Mirage (still to be exploited). It still needs more development after the project as there are still a number of problems preventing HMDs from delivering convincing AR experiences.

WP2 was also a fruitful Workpackage in terms of scientific publications, with four high quality papers being delivered:

1. Kurz, D., BenHimane, S.: "Gravity-aware Handheld Augmented Reality", Proceedings of the 2011 10th IEEE International Symposium on Mixed and Augmented Reality (ISMAR'11), Munich, Germany, 2011
2. Kurz, D., Lieberknecht, S., BenHimane, S.: "Benchmarking Inertial Sensor-aided Localization and Tracking Methods", The 2nd International Workshop on AR/MR Registration, Tracking and Benchmarking (TrakMark2011), Basel, Switzerland, 2011
3. Kurz, D., BenHimane, S.: "Handheld Augmented Reality involving gravity measurements", Computers & Graphics, Volume 36, Issue 7, 2012, pages 866-883, ISSN 0097-8493 (online version of the chapter: http://dx.doi.org/10.1016/j.cag.2012.03.038, accessed September 20th, 2012)
4. Kurz, D., Olszamowski, T., and BenHimane S., Representative Feature Descriptor Sets for Robust Handheld Camera Localization, ISMAR2012, pp. 65-70, Atlanta, Georgia, USA, 2012

3.2. Workpackage 3: User interface and interaction design

The objective of WP3 (User interface and interaction design) was to investigate novel techniques for content presentation in a mixed reality fashion and to design engaging end-user interfaces.

The major achievement of WP3 was the creation of a set of multi-modal indoor and outdoor navigation techniques that were effectively integrated into two system demonstrators. The first of these took the form of a navigator for an indoor environment which acted as a personal shopping assistant for the visually impaired. The second was navigator for an unconstrained outdoor environment and which delivers an Audio-visual guided tour to the city of Grenoble. The user interfaces employed facilitate rich user interactions through the successful integration of several devices: a Smartphone, a Smartwatch, a headset and an ear set.

The AR Personal Assistant uses vibration and audio feedback to inform of pertinent information when needed and exploits touch screen (on both the phone and the watch), motion gestures (from both the phone and the watch) and real-world surfaces thanks to computer vision and hand tracking.

The AR Tour Guide utilizes a mix of visual and audio feedback, through the phone, headphones and/or HMD to produce a truly interactive experience.

The key integrator in both cases was the OSM format whose extension served to define predefined walks, audio-instructions, Point of Interests (POIs), beacons (audio, text), user-confirmations, text nodes and geo-fences. Beacons have been introduced as OSM nodes that enable the system to remap location to an exact and known position given a user's confirmation through their button on headphones, watch, etc... User experiences involving visual recognition technologies are also triggered using geo-fenced Point of Interests around experience locations (geometric shapes).

In short, the major achievement in the WP is the creation of a data centric Augmented Reality (authoring and rendering) Application using a global approach. This approach consists of describing the physical world (maps, ways, geo-fences) and an insertion of virtual objects into the environment (3D audio, instructions, visual experiences, etc.). This enables us to observe mobility-related user-interactions in a data integrative manner. This was only possible by extending the OSM format. User mobility and interactions in the system are possible by combining Pedestrian Dead Reckoning (continuous localization) and Map-aided positioning (matching or projection) to this format. User interactions related to the navigational assistance of visually impaired people and the visually rich cultural tours we have enabled through the integration of computer vision and 3D understanding also involve the triggering of events. The practical experience with users has been carefully evaluated and required several adjustments.

The only aspect that we think could have been done better in this WP concerns the level of integration between the mobile user position tracking and the visual tracking part. Ideally, it should have been more tightly coupled, but this is not an easy task. Furthermore, the integration of indoor positioning based on Wi-Fi networks would have been a plus. And finally, due to the late arrival on the market of Head Mounted Displays, we have only touched upon their potential. A more comprehensive experience with HMDs would also have been a plus.

The most exploitable outcome of WP3 is the creation of the data and format-oriented tool-chain ranging from authoring through to the user experience on the mobile. The current application can be seen as a full AR browser that relies only on remote access to OSM enhanced files to produce an advanced AR experience. This is clearly original compared to other works.

WP3 was also a fruitful Workpackage in terms of scientific publications, with six high quality papers being delivered:

1. Jacques Lemordant, Thibaud Michel, Mathieu Razafinahazo. Mixed Reality Browsers and Pedestrian Navigation in Augmented Cities. The Graphical Web Conference, Oct 2013, San Francisco, United States.
2. P. Chippendale, V. Tomaselli, V. D'Alto, G. Urlini, C.M. Modena, S. Messelodi, M. Strano, G. Alce, K. Hermodsson, M. Razafimahazo, T. Michel, G. Farinella. Personal Shopping Assistance and Navigator System for Visually Impaired People. 2nd Workshop on Assistive Computer Vision and Robotics – ACVR at ECCV Zurich, Switzerland, 12 September 2014

3. Mathieu Razafimahazo, Nabil Layaïda, Pierre Genevès, Thibaud Michel: Mobile Augmented Reality Applications for Smart Cities. ERCIM News 2014(98) (2014)
4. Lorenzo Porzi, Stefano Messelodi, Carla M. Modena, Eliza Ricci. A Smart Watch-based Gesture Recognition System for Assisting People with Visual Impairments. ACM International Workshop on Interactive Multimedia on Mobile and Portable Devices – IMMPD 2013. Barcelona, Spain, 22 October 2013
5. Mauro Dalla Mura, Michele Zanin, Claudio Andreatta, Paul Chippendale. Augmented Reality: Fusing the Real and Synthetic Worlds. IEEE International Geoscience and Remote Sensing Symposium – IGARSS 2012. Munich, Germany, 22-27 July 2012, pp. 170-173
6. Paul Chippendale, Benjamin Prestele, Daniel Buhrig, Peter Eisert, Selim BenHimane, Valeria Tomaselli, Håkan Jonsson, Günter Alce, Yohan Lasorsa, Mauro de Ponti, Olivier Pothier. VENTURI – immersiVe ENhancemenT of User-woRld Interactions (white-paper shared on VENTURI website)

3.3. Workpackage 4: Context Sensing and Interpretation

This Workpackage dealt with the integration of on-board sensors (motion, audio, video plus virtual ones such as Social surroundings) to provide a comprehensive understanding of user context (including the modelling of the surroundings), location and orientation. The WP developed several methods to estimate geographical location and absolute device orientation through the fusion of GPS, digital compass, accelerometers, vision-based algorithms and a-priori knowledge about the World (e.g. 2D maps, Digital Elevation Models, geo-tagged media). User behaviour understanding was also explored through the integration of the sensors from wearables like Smartwatches and HMDs.

The major achievement in WP4 has been the development of a set of algorithms for visual 3D pose estimation which feed the algorithms in WP5 to solidly and realistically place AR objects into the environment. The exploitation of the on-board camera has played a pivotal role in this challenge, with algorithms attempting to estimate absolute position and pose (needed for initialisation purposes) from recognisable/unique features in the environment like mountain profiles, geo-located text, visual landmarks. During periods when these features are not-visible, inertial tracking (PDR) and visual point tracking algorithms like SfM (Structure from Motion) and SLAM are exploited to maintain an updated location and pose estimate.

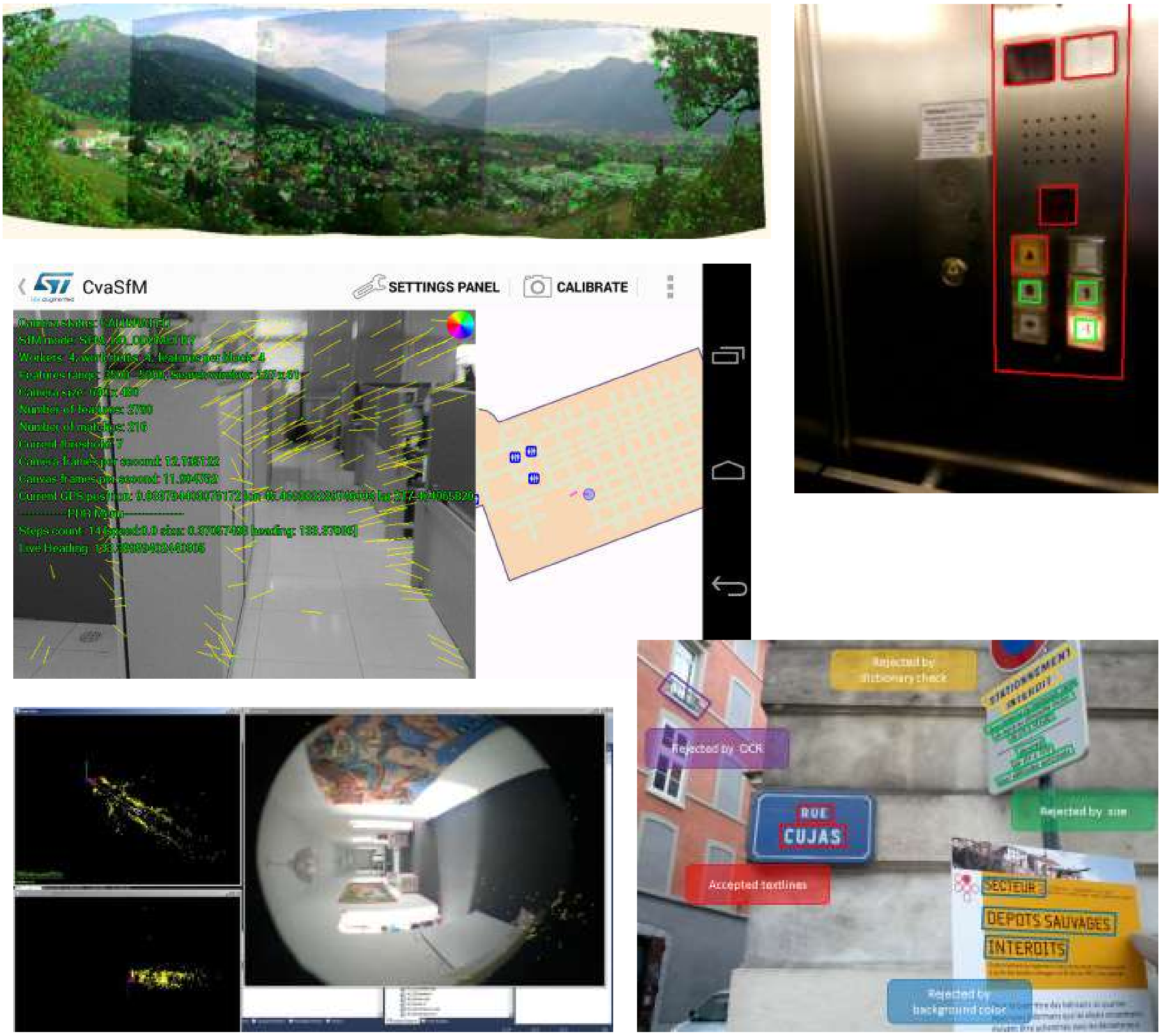


FIGURE 3: VISUAL PROCESSING TO DETERMINE LOCATION AND POSE

Other notable outcomes include Automatic Scene Classification (to discriminate between various contexts, e.g. indoor/outdoor or crowded/not-crowded) and the Map-aided positioning system (to compensate for drifts coming from the inertial sensors by exploiting OpenStreetMap). Both of these technologies were successfully integrated into the 2nd year indoor/outdoor navigator demonstrations to support visually impaired people, providing increased navigational accuracy and context awareness. The Map-aided positioning also proved to be crucial in the outdoor environment of the 3rd year demo where GPS accuracy can be worse than 30m in the dense urban environment of the city.

The only aspect that we would have liked to have seen integrated into the 3rd year demonstrator but wasn't due to a lack of precise 3D models of the city of Grenoble, is the module which directly matches visual content to synthetic models of architecture. This algorithm, explored in the early part of the project, functioned in a similar way to the mountain registration approach, i.e. matching the silhouette of the sky-to-land boundary to a 3D model (the mountain version features in the PanorARma Experience in the 3rd year AR tour). However, in the absence of accurate building models this approach could not be utilised.

The most exploitable outcomes of WP4 have already found their way into the Metaio SDK, namely the improved 3D reconstruction and tracking algorithms. Such algorithms have been available in the SKD for some time, but they have previously been restricted to desktop-size environments. With the improvements developed within VENTURI, it is now possible to extend the scale of reconstructed environments to room-sized spaces, and even to outdoor areas if used by an expert.

WP4 did encounter a few delays; most notably D4.4 which was several months late (eventually submitted at the beginning of the third year) due to the loss of critical staff from more than one partner. However, as this work was independent from other tasks and as it was destined to be included in the third year demonstrator; its delay had no impact on the other tasks running concurrently.

WP4 produced many scientific publications:

1. D. Buhrig, P. Eisert, "Pose Estimation for Urban Environments", Proc. European Conference on Visual Media Production (CVMP), London, UK, Dec. 2012
2. Paul Chippendale, Benjamin Prestele, Daniel Buhrig, Peter Eisert, Selim BenHimane, Valeria Tomaselli, Håkan Jonsson, Günter Alce, Yohan Lasorsa, Mauro de Ponti, Olivier Pothier: "VENTURI – immersiVe ENhancemenT of User-woRld Interactions"
3. Kurz, D., BenHimane, S.: "Handheld Augmented Reality involving gravity measurements", Computers & Graphics, Volume 36, Issue 7, 2012, pages 866-883, ISSN 0097-8493 (online version of the chapter: http://dx.doi.org/10.1016/j.cag.2012.03.038, accessed September 20th, 2012)
4. Kurz, D., BenHimane, S.: "Gravity-aware Handheld Augmented Reality", Proceedings of the 2011 10th IEEE International Symposium on Mixed and Augmented Reality (ISMAR'11), Munich, Germany, 2011
5. Lieberknecht, S., et al, "RGB-D camera-based parallel tracking and meshing", Proceedings of ISMAR 2011, pp. 147-155
6. Porzi, L. et al, "Visual-inertial tracking on Android for Augmented Reality applications, Proceedings of EESMS 2012, pp. 35-41
7. Kurz. D. Et al., "Representative feature descriptor sets for robust handheld camera localization", Proceedings of ISMAR 2012, pp. 65-70
8. Chippendale, P. et al, "Geo-positional Image Forensics through Scene-terrain Registration", Proceedings of VISAPP 2013, pp. 41-47
9. Michel, T., et al, "OSM and micro mobility: mapping with scooters", State of the Map 2013
10. Zen, G., et al, "Simultaneous Ground Metric Learning and Matrix Factorization with Earth Mover's Distance", Proceedings of ICPR 2014
11. Costante, C., et al, "Personalizing a Smartwatch-based Gesture Interface with Transfer Learning", Proceedings of EUSIPCO 2014
12. Blumenthal-Barby, D., et al, "High-resolution depth for binocular image-based modelling", Computer & Graphics, Vol. 39, 2014, Elsevier, pp. 89-100
13. Sangineto, E., et al, "We are not All Equal: Personalizing Models for Facial Expression Analysis with Transductive Parameter Transfer", Proceedings of MM 2014, ACM, pp. 357-366
14. Porzi, L., et al, "Sensor Fusion for Outdoors Augmented Reality on Android", Proceedings of ICDSC 2014
15. Zen, G., et al, "Unsupervised Domain Adaptation for Personalized Facial Emotion Recognition", Proceedings of ICMI 2014, pp. 128-135
16. P. Chippendale, V. Tomaselli, V. D'Alto, G. Urlini, C.M. Modena, S. Messelodi, M. Strano, G. Alce, K. Hermodsson, M. Razafimahazo, T. Michel, G. Farinella. Personal Shopping Assistance and Navigator System for Visually Impaired People. 2nd Workshop on Assistive Computer Vision and Robotics – ACVR at ECCV Zurich, Switzerland, 12 September 2014

3.4. Workpackage 5: Adaptive Content Harvesting, Creation and Delivery

This workpackage dealt with 'user-oriented data' that is used to power the VENTURI platform and covered issues such as 'data flow' (user needs driving the sourcing, harvesting, searching and processing), and the research and development concerning adaptive content creation and delivery methods for virtual objects to be placed into the real world, producing methods for 3D visual reconstruction/insertion and visual content fusion.

The major achievement in WP5 has been the development of a set of tools for 3D content creation and AR content delivery which power the AR scenarios implemented within VENTURI. This also includes audio content as well as semantic data.

In particular, a 3D reconstruction pipeline for different kinds of datasets has been successfully established. A major achievement are the methods for the reconstruction of 3D real-world objects of different sizes and characteristics: ranging from small artefacts that can be captured in a controlled lab environment (Figure 4), to larger scale objects, such as art monuments or statues, which require acquisition on-site (Figure 5). Furthermore, approaches to perform 3D reconstruction from sparse and dissimilar datasets, such as collections of old photographs and paintings (Figure 6) have been successfully developed in this work package producing some very impressive results. The 3D content created by these tools has been included in all of the VENTURI demonstrator platforms.

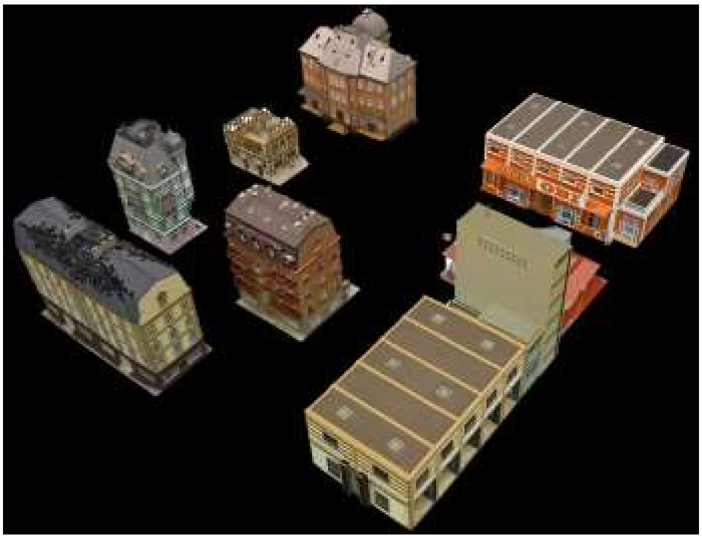


FIGURE 4: RECONSTRUCTION OF SMALL SIZED MODEL HOUSES IN A LAB ENVIRONMENT

FIGURE 5: RECONSTRUCTION OF A STATUE IN AN OUTDOOR ENVIRONMENT

FIGURE 6: 3D REPRESENTATION CREATED FROM VINTAGE PICTURE

Another notable achievement was the development of the Web-of-Data pipeline which enables the VENTURI platform to crawl, extract and curate semantic data available in the internet. A tool chain has been created to collect and process the data and make it available through an API.

The only aspect that we think could have been done better in this WP concern the methods created for content delivery that could have been better integrated into the mobile platform used for the VENTURI demonstrators. For example, methods for 3D content fusion (i.e. natural illumination estimation and image appearance synchronization) have been successfully developed as research prototypes running on PCs. However, they are not available on a mobile platform. Porting these methods to a mobile platform involves adaptations to the available resources (CPU and RAM) while still ensuring real time capabilities, which basically means to re-write whole algorithms or established tool chains which requires a lot of efforts.

The most exploitable outcome of WP5 is the 3D reconstruction tools which could be used to generate high quality 3D content. Another exploitable outcome is the Web-of-data pipeline that realizes a full acquisition and a processing pipeline; this has already been exploited by other projects.

WP5 did encounter a few delays; most notably D5.4 (and the associated task T5.1) which was late by 3 months due to late research results. It was also set-back because we wanted to test the developed methods at a technical meeting in Grenoble in September 2014 before submitting the deliverable. By delivering preliminary results we ensured that these delays did not have any impact on the overall project. D5.5 and D5.7 were also late by 2 months, but they did not have any impact on the overall project.

WP5 has produced several scientific publications:

1. D. Buhrig, P. Eisert, "Pose Estimation for Urban Environments", Proc. European Conference on Visual Media Production (CVMP), London, UK, Dec. 2012
2. D. Blumenthal-Barby, P. Eisert, High-Resolution Depth for Binocular Image-Based Modelling", Computers & Graphics, vol. 39, pp. 89-100, Apr. 2014.
3. Paul Chippendale, Benjamin Prestele, Daniel Buhrig, Peter Eisert, Selim BenHimane, Valeria Tomaselli, Håkan Jonsson, Günter Alce, Yohan Lasorsa, Mauro de Ponti, Olivier Pothier: "VENTURI – immersiVe ENhancemenT of User-woRld Interactions"
4. Jonsson, H.: "A comparison of Facebook friendship and physical proximity", NetSci 2013, Copenhagen
5. Jonsson, H., Nugues, P.: "Proximates – A Social Context Engine", in Communications and Computer and Information Science, Volume 413, 2013, pp 230-239

6. Jacques Lemordant, Thibaud Michel and Mathieu Razafimahazo: “Customizable Interactive Audio Rendering of OSM Maps”, State of the Map 2013, Birmingham

3.5. Workpackage 6: Technology Integration, Evaluation and Test-cases

This workpackage dealt with the integration of VENTURI components from Workpackages WP3, WP4 and WP5 based on the specifications defined in WP2. Integrated demonstrators were released at yearly intervals (M12 M24, M36) in the form of technology demonstrators that targeted AR scenarios with increasing difficulties. These demos were evaluated and validated using user feedback in WP3.

FIGURE 7: PROTOTYPE PLATFORM USED TO PERFORM SYSTEM ANALYSIS, E.G. BOTTLENECK IDENTIFICATION

Extensive profiling aimed at the identification of system bottlenecks was carried out in the first half of the project, to aid in the use-case definitions, SW integration and AR algorithmic development. Improvements to the overall user experience were also validated with the integration of a framework for Quality of Service tailored to the use-cases for the different usage scenarios and in a variety of environmental conditions and platform specifications.

The major achievement of the WP6 was the successful integration of the three Android applications that constituted the tech demos. This endeavour was the glue that helped to create a strong team spirit through optimizing algorithm performances, harmonising contributions and the releasing of prototypes that were more than simply the sum of their parts. Throughout all stages of development this WP evaluated the positive and negative aspects of the elements and the whole to help improve the whole project in an iterative way. Thus the analysis enabled improvements such as resource usage, improved look, feel and functionality, leading to an improved quality of experience.

Many hardware-specific optimizations were performed on the first and second VENTURI platforms supplied by ST-Ericsson that showed the benefit of gaining access to very low level parameters. However, for the 3rd demonstrator a commercial device was selected (from partner Sony) to ensure that the technologies that had been developed would run on consumer level equipment.

The final demo, the tourist AR navigator, can be considered the most exploitable aspect of the Workpackage. It has been realized as a free distribution, so it is ready to be used by external users.

Unfortunately, Milestone MS15 was substantially delayed by 8 months due to unforeseen changes from the VENTURI hardware platform (ST-Ericsson 9540 development platform) to the SONY Xperia commercial platform (brought about by the closure of the ST-Ericsson partnership).

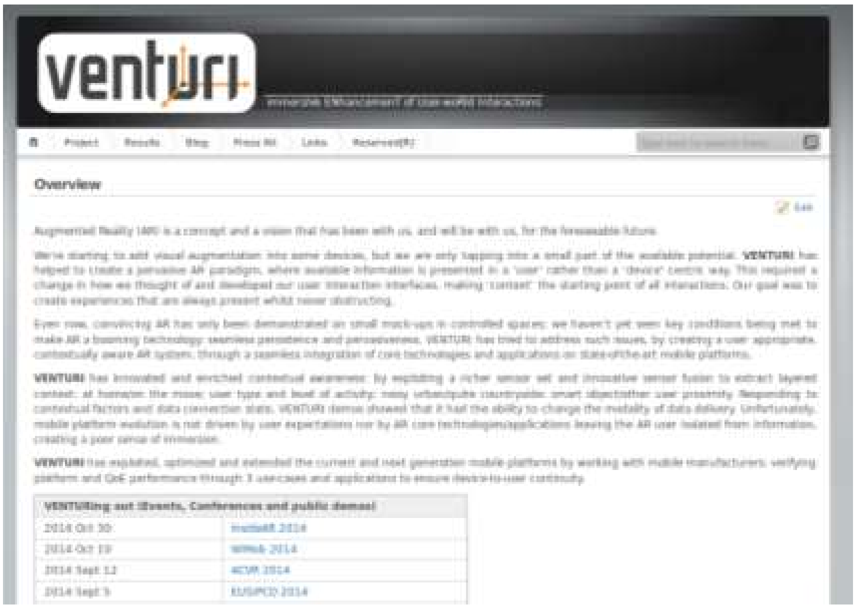
The meant that we had to spend resources porting and optimising algorithms for the new platform thus losing control of some hardware components (e.g. sensor to camera synchronisation). However, this was a fruitful investment, as there was no loss in AR performance or experience and afterwards we could run VENTURI algorithms on any new Android device.

4. Potential impact, main dissemination activities and exploitation of results

In this section, information concerning the project's potential impact, main dissemination activities and exploitation of results can be found.

4.1. Online presence

VENTURI's website can be found here: https://venturi.fbk.eu/ and on it you can find a wide variety of results and information about the project. It will continue to be maintained and updated with new dissemination activities (see Blog section) for the foreseeable future.



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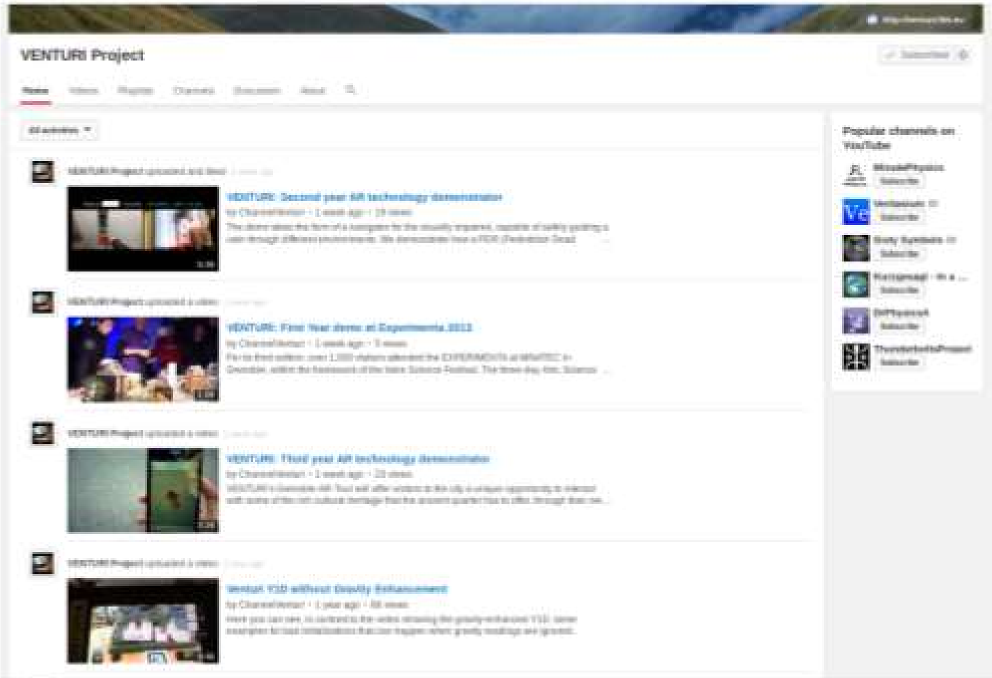
4.3. Project logo

4.4. Promoting VENTURI

From Day 1 we wanted VENTURI to address and help real-people and so at every opportunity we tried to spread the word to the public about our research and outcomes. Thanks to the engaging and intuitive nature of the research we found that the public wanted to know how it worked, how they could explore the technology for themselves and when they could have it on their phones. In this section we have assemble a few images from our promotion of the project spanning public open days to scientific presentations at top ranking conferences.

A series of YouTube videos are also available, which illustrate participation in events or specific technologies developed: https://www.youtube.com/user/ChannelVenturi



4.5. Use and dissemination of foreground

During the first few months of the project, the VENTURI consortium thought about the best strategy to disseminate the results and knowledge generated inside the project. As all of the partners already had a long experience in such matters, we quickly agreed upon an approach that reflected the entire AR pipeline reaching from academic research through to pre-product development. As the consortium is made up of partners from the entire spectrum of the AR pipeline, i.e. from industry to Application developers, it made sense to create dissemination material that was tailored towards the needs of each individual stakeholder group being presented to. To address this need and to minimise its demand on resources, we created a private section inside the VENTURI website which hosted common dissemination material that could be adapt to specific needs. This 'fundamental' material also helped to create a level of consistency across all of VENTURI's presentation material, thus reinforcing the strong team/collaborative nature of the consortium from an outsider's perspective.

During the negotiation phase of the project, the Project Officer hinted that the Commission really appreciated solid outcomes from its new projects, so the idea of creating 'End of Year' demos was written into the DoW. As a result, three demonstrators were to be created (one at the end of each year) that each aimed to address real problems and challenges faced in the Augmented Reality domain. The first year demo focused on the creation of an indoor, table top, AR game (Published on Google Play as VENTURI Flyer app). The second year demo focussed on the creation of a mobile-based assistant for the visually impaired. Finally, the third year demo focussed on the creation of an AR tourist application. These different 'target audiences' gave the project the opportunity to spread its knowledge to a wider range of stakeholders than was originally expected; hence the figure above was also adapted to the yearly demonstrators.

As our dissemination objectives focused on the raising of interest levels in those that had no knowledge of AR and also those that already had some fundamental curiosity about our research, VENTURI's hands-on demos provided a natural and intuitive way to break the ice during events. Moreover, as almost everyone has a Smartphone, the demos we instantly engaging and provided an optimal dissemination platform.

In the final year of the project, we were very happy to work with Florent Blanc from the Ecole de la Paix in Grenoble who gave the project a massive new audience to educate about the outcomes of VENTURI. VENTURI's dissemination strategy was applied to its new target audience: schoolchildren who were gathering data for the year 3 demo and visitors to the Grenoble who would be given a new way of exploring the city. To achieve maximum dissemination effectiveness, we decided to create an App that would be publically shared on the Google play store to showcase the results of the project (soon to be released).

Throughout the three years of the project, the consortium has also maintained a strong commitment to academic dissemination activities, and has thus generated many publications at world-renowned conferences.

4.6. Dissemination beyond the End of the Project

Many of the research activities linked to VENTURI will continue to run beyond the end of the project, both in terms of dissemination and exploitation. In this section, we list a few examples of how VENTURI's efforts will be kept alive.

The Tyrex team (partner INRIA) is enhancing the technology built with the VENTURI Project. Thibaud Michel has started a PhD in pedestrian navigation. The Yr3 demo Application has been designed to be used by Grenoble citizens or tourists. This application will be available on the Google Play Store in two languages (French and English) as soon as content will be available. The AR Experiences will be separated from main application enabling us to add or remove specific Experiences in a dynamic way. The Tyrex team will design a full-scale audio tour of Grenoble featuring navigation instructions and substantial cultural content.

In parallel, the team is in contact with several start-up companies in order to transfer the technology in the form of an SDK. This SDK covers indoor and outdoor pedestrian navigation with augmented and virtual reality capabilities. In particular, it includes 3D audio, panoramas, Points of Interest (POIs), pictures and vector graphics for both augmented and virtual reality. The team has also designed an authoring tool for content and navigation on top of JOSM with extension to OpenStreetMap format. The tool is capable of describing declaratively the entire facets of the application using geo-fences as triggers for augmented reality experiences.

After the conclusion of the project, FBK will generate a press release that sums up the project's successes to publicise the positive aspects of the collaboration. This will be distributed to the local newspapers and placed on FBK's main webpage.

On the 18th November FBK will host an AR stand in the new MUSE museum in Trento for the Marie Skłodowska-Curie Actions 2014 Conference. The EU2014 conference on The Empowerment of the Next Generation of Researchers "Promoting talents, spreading excellence" is organised by the Italian Ministry of Education, Universities and Research in collaboration with the Autonomous Province of Trento.

Like INRIA, FBK also plans to create an AR Experience by re-deploying the technologies creating inside the project. For the city centre of Trento, FBK will create an iStreet App that will inform locals and tourists about local attractions and the history behind the naming of the street, thus providing a further opportunity to promote the outcomes of the project.

Fraunhofer HHI will showcase the VENTURI technology in its 3IT Innovation Centre. This showroom is organized in close collaboration with around 40 partners from industry with the aim of technology transfer. With around 50 events per year, this facility attracts a large number of professional visitors and organizations and provides a good platform for disseminating VENTURI results.

In addition, Fraunhofer HHI and e-Diam have agreed to further develop and showcase parts of the VENTURI mobile content creation technology for real estate applications (plus we are also trying to contribute to the MPEG standards in Visual Search, of which e-Diam is a member). Fraunhofer HHI, as a research institute, will disseminate the results at international conferences and workshops as well as marketing events and fairs.

Metaio will present the VENTURI research project at its annual insideAR 2014 conference on augmented reality, taking place in Munich at the end of October. A typical part of the conference is the presentation of funded research projects that Metaio is involved in. VENTURI will be shown in that context at a booth dedicated to research projects.

5. Dissemination Activities Tables

List of scientific (peer reviewed) publications										
No.	**Title**	**Main author**	**Title of the periodical**	**Number, date or frequency**	**Publisher**	**Place of pub.**	**Year**	**Pages**	**Permanent identifiers**	**Is open access provided to this publication?**
1	Handheld Augmented Reality involving gravity measurements	Kurz, D	Computers & Graphics	Volume 36, Issue 7, 2012	Elsevier		2012	866-883	http://dx.doi.org/10.1016/j.cag.2012.03.038	no
2	Gravity-aware Handheld Augmented Reality	Kurz, D	Proceedings of ISMAR 2011	2011	IEEE		2011	111-120	http://dx.doi.org/10.1109/ISMAR.2011.6092376	no
3	RGB-D camera-based parallel tracking and meshing	Lieberknecht, S.	Proceedings of ISMAR 2011	2011	IEEE		2011	147-155	http://dx.doi.org/10.1109/ISMAR.2011.6092380	no
4	Benchmarking Inertial Sensor-aided Localization and Tracking Methods	Kurz, D.	Proceedings of TrakMark2011	2011			2011		http://ypcex.naist.jp/trakmark/Workshop11/2011wsproc/pdfs/Kurz.pdf	yes
5	Queries in the Augmented Town	Lemordant, J.	6th European Forum on eAccessibility	2012			2012			yes
6	Augmented Reality at FBK	Chippendale, P.	GIRPR 2012	2012			2012			yes
7	Augmented reality: Fusing the real and synthetic worlds	Della Mura, M.	Proceedings of IGARSS 2012	2012	IEEE		2012	170-173	http://dx.doi.org/10.1109/IGARSS.2012.6351610	no

8	Feature preserving method for creating visual appearance models and virtual views from collective images	Zanin, M.	Proceedings of IGARSS 2012	2012	IEEE		2012	56-59	http://dx.doi.org/10.1109/IGARSS.2012.6351638	no
9	Visual-inertial tracking on Android for Augmented Reality applications	Porzi, L.	Proceedings of EESMS 2012	2012	IEEE		2012	35-41	http://dx.doi.org/10.1109/EESMS.2012.6348402	no
10	Representative feature descriptor sets for robust handheld camera localization	Kurz. D.	Proceedings of ISMAR 2012	2012	IEEE		2012	65-70	http://dx.doi.org/10.1109/ISMAR.2012.6402540	no
11	Pose Estimation for Urban Environment	Buhrig, D.	CVMP 2012	2012			2012			Yes
12	Geo-positional Image Forensics through Scene-terrain Registration	Chippendale, P.	Proceedings of VISAPP 2013	2013			2013	41-47	http://dx.doi.org/10.5220/0004282300410047	No
13	A comparison of Facebook friendship and physical proximity	Jonsson, H.	International School and Conference on Network Science	2013			2013	13	https://lup.lub.lu.se/search/publication/4193997	No
14	WozARd: a wizard of oz tool for mobile AR	Alce, G.	Proceedings of MobileHCI 2013	2013	ACM		2013	600-605	http://dx.doi.org/10.1145/2493190.2494424	No
15	Customizable Interactive Audio Rendering of OSM Maps	Lemordant, J.	State of the Map 2013	2013			2013			Yes
16	OSM and micro mobility: mapping with scooters	Michel, T.	State of the Map 2013	2013			2013			Yes
17	Mixed Reality Browsers and Pedestrian Navigation in Augmented Cities	Lemordant, J.	Proceedings of Graphical Web 2013	2013			2013		https://hal.inria.fr/hal-00872721	Yes

18	Proximates – A Social Context Engine	Jonsson, H.	Communications in Computer and Information Science	Volume 413, 2013	Springer		2013	230-239	http://dx.dor.org/10.1007/978-3-319-04406-4_23	No
19	Proximity-based reminders using Bluetooth	Jonsson, H.	Proceedings of PERCOM 2014	2013	IEEE		2013	151-153	http://dx.doi.org/10.1109/PerComW.2014.6815184	No
20	A comparison of two proximity networks	Jonsson, H.	Proceedings of ISSNIP 2013	2014	IEEE		2013	1-5	http://dx.doi.org/10.1109/ISSNIP.2014.6827693	No
21	Simultaneous Ground Metric Learning and Matrix Factorization with Earth Mover's Distance	Zen, G.	Proceedings of ICPR 2014	2014			2014			Yes
22	Personalizing a Smartwatch-based Gesture Interface with Transfer Learning	Costante, C.	Proceedings of EUSIPCO 2014	2014			2014			Yes
23	High-resolution depth for binocular image-based modeling	Blumenthal-Barby, D.	Computer & Graphics	Vol. 39, 2014	Elsevier		2014	89-100	http://dx.doi.org/10.1016/j.cag.2013.12.001	No
24	We are not All Equal: Personalizing Models for Facial Expression Analysis with Transductive Parameter Transfer	Sangineto, E.	Proceedings of MM 2014	2014	ACM		2014	357-366	http://dx.doi.org/10.1145/2647868.2654916	No
25	Sensor Fusion for Outdoors Augmented Reality on Android	Porzi, L.	Proceedings of ICDSC 2014	2014	IEEE		2014			No
26	Unsupervised Domain Adaptation for Personalized Facial Emotion Recognition	Zen, G.	Proceedings of ICMI 2014	2014	ACM		2014	128-135	http://dx.doi.org/10.1145/2663204.2663247	No

General list of Dissemination activities								
NO.	**Type of activities**	**Main leader**	**Title**	**Date**	**Place**	**Audience**	**Size of audience**	**Countries addressed**
1	Trade show	metaio	Mobile World Congress	February, 2012	Barcelona, Spain	Industry	10000s	Worldwide
2	Conference	metaio	ISMAR	September, 2011	Munich, Germany	Academic/Industry	1000s	Worldwide
3	Conference	metaio	ISMAR	September, 2012	Atlanta, Georgia, USA	Academic/Industry	1000s	Worldwide
4	Trade show	metaio	Mobile World Congress	February, 2013	Barcelona, Spain	Industry	10000s	Worldwide
5	Conference	FBK	International Conference on Multimodal Interaction	November, 2014	Istanbul, Turkey	Academic	1000s	Worldwide
6	Conference	FBK	Association for Computing Machinery	November, 2014	Florida, USA	Academic	1000s	Worldwide
7	Conference	FBK	ICPR	August, 2014	Stockholm, Sweden	Academic	100s	Worldwide
8	Conference	FBK	VISAPP	February, 2013	Barcelona, Spain	Academic	100s	Worldwide
9	Conference	Sony	Telematics Munich	November, 2011	Munich, Germany	Academic	100s	European
10	Conference	Sony	EBE	September, 2012	Seville, Spain	Academic	100s	European
11	Event	e-Diam	Jornada Aumentame Congress	April, 2012	Tarragona, Spain	General audience	100s	Spain
12	Conference	metaio	TrakMark	October, 2011	Basel, Switzerland	Academic	100s	European
13	Conference	INRIA	European Forum on e-Accessibility	March, 2012	Paris, France	Academic	100s	European
14	Conference	FBK	GIRPR	September, 2012	Siena, Italy	Academic	100	Italian
15	Conference	FBK	IGARSS	September, 2012	Munich, Germany	Academic	1000s	Worldwide
16	Conference	INRIA	State Of The Map	September, 2012	Tokyo, Japan	Academic	100s	Worldwide
17	Conference	FBK	IEEE Workshop on Environmental, Energy, and Structural Monitoring Systems	September, 2012	Perugia, Italy	Academic	100s	Worldwide

18	Standards	ST-E	AR Standards Community Meeting	July, 2012	Geneva, Switzerland	Academic/In-dustry	50	European
19	Conference	Fraunho-fer	CVMP	December 2012	London, UK	Academic/In-dustry	100s	European
20	Conference	Fraunho-fer	MIRAGE	June, 2013	Berlin, Ger-many	Academic	100s	European
21	Conference	INRIA	State Of The Map	September, 2013	Birmingham, England	Academic	100s	Worldwide
22	Conference	Sony	MobileHCI	August, 2013	Munich, Ger-many	Academic	100s	European
23	Standards	Sony	AR Standards Community Meeting	September, 2014	Munich, Ger-many	Academic/In-dustry	50	European
24	Conference	Sony	IHCI	September, 2014	Evry, France	Academic	100s	European
25	Conference	FBK	ACVR	September, 2014	Zurich, Swit-zerland	Academic	100	Worldwide
26	Conference	FBK	EUSIPCO	September, 2014	Lisbon, Por-tugal	Academic	100s	European
27	Conference	FBK	ACM Multimedia	November, 2014	Venice, Italy	Academic	100s	Worldwide