Combining MIMO Radar with MU-MIMO Communications: More than Coexistence (ComRad)

Rapports

Informations projet

ComRad

N° de convention de subvention: 793345

Site Web du projet

DOI
10.3030/793345

Projet clôturé

Date de signature de la CE
12 Avril 2018

Date de début
1 Novembre 2018

Date de fin
31 Octobre 2020

Financé au titre de
EXCELLENT SCIENCE - Marie Skłodowska-Curie Actions

Coût total
€ 183 454,80

Contribution de l'UE
€ 183 454,80

Coordonné par
UNIVERSITY COLLEGE LONDON
United Kingdom

Periodic Reporting for period 1 - ComRad (Combining MIMO Radar with MU-MIMO Communications: More than Coexistence (ComRad))

Période du rapport: 2018-11-01 au 2020-10-31

Résumé du contexte et des objectifs généraux du projet

1. Objectives

The goal of ComRad is to develop novel signal processing techniques for transmit and receive beamforming, waveform design, signal classification/recognition, and channel estimation, to enable the exploitation of radar spectrum for communication applications, with particular focus on 1) Coexisting Communication and Radar Systems (C-ComRad), and 2) Dual-functional Communication-Radar Systems (D-ComRad). The main research approaches that will be employed include the cutting-age concepts of interference exploitation, manifold based optimization and machine learning. The research outputs will have a significant impact on the applicant's career prospects enabling him to obtain a leadership position in academia or industry. More importantly, it will also contribute to the efficient usage of the spectrum, which is closely related to the economic future of the European Union (EU), especially the digital communication for essential public services such as defense, police and emergency services.

Overall assessment: The project has fully achieved its objectives and milestones for the period.

Objective I. C-ComRad that is mutually beneficial to both radar and communication systems: develop low-complexity transmit-receive schemes for the coexisting radar and multi-user communications under both cooperative and non-cooperative scenarios.

Objective II. D-ComRad by dual-funcational ComRad system designs and optimisation: a) waveform design for radar detection that carries information, b) joint target detection and channel estimation, c) low-complexity transmit beamforming design for interference exploitation, d) signal recognition/classification using machine learning.

Objective III. To demonstrate the elementary function of ComRad design in a relevant environment: a) To develop an overarching system-level simulator that evaluates performance on a network level, and using standards-relevant transmission, b) elementary
proof of concept software-defined-radio (SDR) demo using USRPs and LabVIEW to validate the developed CRSS approaches.

Travail effectué depuis le début du projet jusqu'à la fin de la période considérée dans le rapport et principaux résultats atteints jusqu'à présent

Results and progress

WP1: Signal Processing for Coexisting Communication and Radar Systems (C-ComRad)

T1.1 Interference Channel Estimation using Radar Signals as Pilots
We study the interfering channel estimation between coexisted MIMO radar and MIMO base station (BS), where the radar is operated in the "search and track" mode, and the BS receives the

interference from the radar.

T1.2 Power-efficient Transmit Beamforming Enabled by Interference Exploitation
We propose a novel approach to enable the coexistence between Multi-Input-Multi-Output (MIMO) radar and downlink multiuser multi-input single-output communication system. By exploiting the constructive multiuser interference (MUI), the proposed approach tradeoff useful MUI power for reducing the transmit power, to obtain a power efficient transmission.

T1.3 Receiving Techniques for Interference Mitigation
In C-ComRad scenarios, the BS may receive both the target echoes and the UL signals, as the two types of signals may partially overlap with each other, we propose to exploit the non-overlapped part of the radar echoes to recover the overall radar signal, and then subtract its interfrence to the UE's signal by successive interference cancellation (SIC).

WP2: Signal Processing for Dual-functional Communication-Radar Systems (D-ComRad)

T2.1 Multi-functional Waveform Design for Target Detection, Channel Estimation and Communications
We propose multi-input multi-output (MIMO) beamforming designs towards joint radar sensing and multi-user communications. We employ the Cramer-Rao bound (CRB) as a performance metric of target/channel estimation, under both point and extended target scenarios.

T2.2 Joint Symbol-level Transmit Beamforming using Manifold optimisation and Interference Exploitation
We focus on a dual-functional multi-input-multioutput (MIMO) radar-communication (RadCom) system, where a single transmitter with multiple antennas communicates with downlink cellular users and detects radar targets simultaneously. Several design criteria are considered for minimizing the downlink multiuser interference.

T2.3 Joint Receiving based on Signal Recognition and Classification
In D-ComRad scenarios, the BS may also receive both the target echoes and the UL signals, in which case the method adopted in T1.3 can be applied unaltered. On top of that, we have also proposed a tailored D-ComRad frame structure for coordinating the radar and communication operations.

WP3: Demonstration and Verification for the Proposed CRSS Approaches

T3.1 System-Level Simulations for the Proposed CRSS Approaches
We have built system-level simulators based on both MATLAB and LabVIEW. The LabVIEW platform was built during the secondment at Athens Information Technology (AIT), Athens, Greece, where the Research Fellow was hosted by Prof. Constantinos Papadias, IEEE Fellow, the Dean of AIT, as a Visiting Scholar. Fig. 1 shows the UI of the simulator built by LabVIEW.

T3.2 Basic Hardware Demo using USRP and LabVIEW
We have also bulit a basic D-ComRad hardware demo using USRP-2935R, as shown in Fig. 2,

provided by the UCL's Aeroflex lab. We have tested basic communication transmission performance and the radar beampattern performance of the designed D-ComRad waveform in T2.2 of WP2, with a 6-antenna MIMO BS and 2 single-antenna users. The results are shown in Fig. 1, where the tradeoff between a QPSK constellation and a omnidirectional MIMO radar beampattern has been explicitly shown. One can adjust the weights for comms and radar given the specific preference. The experimental results prove again the effectiveness of our D-ComRad designs.

Progrès au-delà de l'état des connaissances et impact potentiel prévu (y compris l'impact socio-économique et les conséquences sociétales plus larges du projet jusqu'à présent)

Impact on the researcher's career

a) The researcher has been supported by the fellowship as a Research Fellow at UCL, one of the world's top universities, working with world-renowned researcher in Wireless Communications, Prof. Christos Masouros.
b) The researcher has published 30+ papers on premier journals and conferences.
c) Together with the supervisor, the researcher has organized a number of academic events in flagship conferences.
d) Together with the supervisor, the researcher has organized two special issues on top IEEE journals.
e) The researcher has been recruited as an Associate Editor of the IEEE Communications Letters.
f) Finally, the researcher joined the Southern University and Technology (SUSTech), China, as an Assistant Professor, thanks to the support of the fellowship.

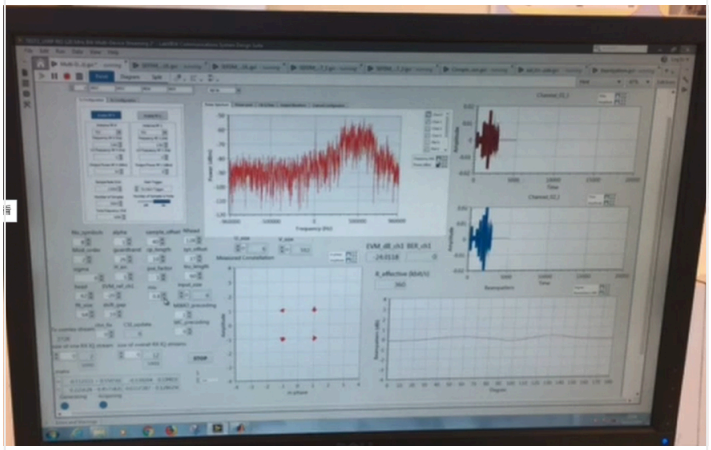
The researcher will actively seek for project collaborations with telecommunications companies in the next few years.

Given the fact that, as per the grant agreement UCL is the owner of the results and they need to protect them, the researcher will not pursue commercialization of the generated results from ComRad with these companies. Instead, the researcher will collaborate with companies in the following ways:

1.Co-organize conference events with companies related to ComRad;
2.Co-organize industry panels with companies related to ComRad;
3.Co-organize webinars on the related topics with companies;
4.Co-author research papers with companies on new results that are not generated from ComRad project;

The researcher would like to emphasize again on that the ownership of the results in ComRad will not be transferred to non-EU companies. UCL will be the owner of the results generated from ComRad under any circumstances.

USRP-2935R platform



System-level simulator

Dernière mise à jour: 19 Juillet 2021

Permalink: https://cordis.europa.eu/project/id/793345/reporting/fr