6G Research Visions

WEBINAR SERIES

Localization and Sensing – Technologies, Opportunities and Challenges

Questions and Answers

Q&A for Localization and Sensing – Technologies, Opportunities and Challenges

How much size is the IRS required for effective area control? Could you please exemplify with a typical use case?

A typical IRS would require several tens of the number of antennas as reflecting elements for achieving the same beamforming performance. This can be roughly estimated by the fundamental power scaling law and the double path loss model of IRSs [1]. However, especially in the context of sensing and localization, different IRS technologies (continuous vs. discrete) provide different performance metrics

[1] Qingqing Wu, S. Zhang, B. Zheng, C. You, and R. Zhang, "Intelligent Reflecting Surface Aided Wireless Communications: A Tutorial,'' IEEE Transactions on Communications, submitted, 2020.

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From the presentation of Hadi, mentioned the use of Intelligent surface for the 6G. I would like to ask, how practical it is to using this proposed idea for the communicationperformance enhancement? From the cost point of view and installation point of view, how practical is the use of RIS? As I believe the fabrication of the THz devices will be much expensive. And the heat energy from the MMIC transceiver for controlling the RIS will also introduce the problem especially at these THz. Thanks.

Several promising use cases make IRSs attractive for enhancing communication system performance. From the cost point of view, most of the cost reduction comes from reducing power consumption. For instance, more than 90% power consumption is noted because of the lack of RF chains. IRSs are also very easy to deploy and very promising for high-frequency operations, especially at the THz band where massive MIMO may not be feasible and where sensing applications thrive.

With active THz-operating LISs, larger arrays with relatively low power could make up for the same link budget/range. In this case, the generated heat is lower because of the lower total power consumption. Furthermore, heat is easier to dissipate since the chip-package-air interface thermal stress would be more spread over a larger area. However, quantitatively, real THz-operating IRS systems are far away, making it hard to produce clear statements.

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If I got this right, one usage of RIS is to beamform the signal to the served users. Have these surfaces the property to beamform the signal or do they make use of a beamforming algorithm? Which beamforming technique is the most used in practice?

Beamforming in the presence of IRSs is typically performed via a joint optimization of beamforming at the base station and phase shifting at the reflecting elements of the IRS. For a specific objective, an optimization problem can be formulated and solved. Such techniques mainly depend on the degree of reconfigurability of the IRS, whether we can introduce a discrete set of phase shifts per reflecting element or a continuous phase shift.

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What is the killer sensing use cases for 6G?

I can imagine that the first large-scale application will be in vehicular automation, as cars already extensively use radars. They can profit from the new bands allocated for 6G and use communications channel for radar interference management. In the longer run, I don’t think there will be a single killer application, as many new applications will surely make use of radar, like intrusion detection, gesture recognition, drones and robotics, health monitoring, and many others yet to come.

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I think that reflection and deflection are necessary as functions of the IRS. Is it possible to use metasurfaces to provide sufficient performance for adaptive area control, especially with respect to deflection? What has been achieved at present and what are the challenges?

Currently, most of the surfaces only support reflection because of its high efficiency. Deflection is not considered due to its low efficiency as the signal has to penetrate something, thus making it less attractive from the implementation perspective. However, this might be attractive from a sensing perspective.

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Where do you see sensing happening most efficiently in 6G? Is it on the UE side or is it on the network side?

In both. The UE side can have access to sensing information instantly and locally, but the network will surely have more capabilities (data processing, hardware). Sensor fusion, combining information from the UE (and other UEs) and the network will certainly play an important role.

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Do you see sensing, RADAR, and localization as three different areas in 6G?

I see them as different services that can be provided by 6G, along with communications, of course. Sensing goes beyond radar, which is a particular sensing application using RF. Anyway, sensing and localization can also profit from each other to improve their accuracy.

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Question for Prof Jaakko Suutala, about new tailed waveformd, like OTFS. Is it always the case when we have a better waveform, that we always have a higher PAPR?

I assume that better means the performance gains of OTFS compared, e.g., to OFDM in some of the new use cases (e.g., radar communication and sensing). No, the usage of OTFS does not always lead to a higher PAPR (see the analysis e.g., in [2] and [3]).

[2] G. D. Surabhi, R. M. Augustine and A. Chockalingam, "Peak-to-Average Power Ratio of OTFS Modulation," in IEEE Communications Letters, vol. 23, no. 6, pp. 999-1002, June 2019.

[3] Hossain, M.N., Sugiura, Y., Shimamura, T. et al. DFT-Spread OTFS Communication System with the Reductions of PAPR and Nonlinear Degradation. Wireless Pers Commun 115, 2211–2228 (2020).

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Won't chirp-based waveform have a hit on achievable communication capacity?

The main difficulty with chirp-based communications at high transmission rates is to have an efficient equalization, which can of course be efficiently done with OFDM, or, with its chirp-based variation, OCDM. Anyway, transceiver complexity is definitely an issue with OFDM/OCDM, particularly regarding the ADC at very high bandwidths. We believe that chirp-based transceivers can be more cost efficient, especially for radar, and, also, maybe we don’t always need a high spectral efficiency, due to the high bandwidths, and we can move towards the power-limited regime, with less complex transceivers.

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How do you evaluate the potential of visible bands for sensing (indoor and outdoor), given the emergence of RIS?

Adapting the phase gradients of a metasurface array reflector can extend the localization and sensing functionalities at the visible bands by extending the coverage area (seeing behind obstacles) and increasing the received signal strength. Mirror arrays with tunable orientations can also achieve the required power focusing.

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Very interesting presentations and I can´t help not to notice the width of the topics adressed. 3GPP placed a lot of emphasis on 5G positioning capabilities in the last years and 5G promises accuracy <1 m in indoor areas and <1m (hybrid high accuracy GNSS+5G), of course depending always on the density of transmitting points in the vicinity of the user. Won´t the 5G - GNSS pair be enough to support all foreseeable applications? Could you please clarify why do we need such a different 6G positioning? Thank you.

5G NR introduced large bandwidth, very high carrier frequency, and massive antenna array offer great opportunities for accurate localization in present-day communication systems. Notice that 6G systems will continue the movement towards even higher frequency operation, e.g., at the mmWave as well as THz spectrum, and much larger bandwidths. In fact, the THz frequency range offers great opportunities, not only for accurate localization, but also for high definition imaging and frequency spectroscopy. Thus, a plethora of new applications becomes viable such as RT robotic control, gesture detection, high-resolution RF imaging, and centimeter-level positioning.

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Are the presentations that we attended today recorded? Where can I find the record?

The video recording is already available in YouTube https://youtu.be/tStqgX2spxo and in the webinar landing page https://www.6gchannel.com/items/6g-research-visions-webinar-series-localization-and-sensing-technologies-opportunities-and-challenges/ along with the slide sets.

Q&A for Localization and Sensing – Technologies, Opportunities and Challenges

How do you consider the integration of more complex sensing solutions in the wireless communications systems will not be an impediment to achieve the expected performance indicators like throughput less than 100Gbit/s, latency less than 1ms, and the feature of ultra-reliable low latency communications?

Sensing might be even an enabler. To begin with, we will have more spectrum, as we can share the spectrum that is currently exclusively allocated for radars, and avoid such exclusive allocations in the future. Secondly, knowledge about the environment obtained from sensing and allocation, may help us in a more efficient beam management. However, of course, depending on the demands on sensing services, there will also be a competition for resources, and a new sensing/communications MAC layer is needed.