PhD Interview

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Overview

1. Background
   - Education background
   - Awards
2. Research Experience
   - Estimate High-fidelity 3D Human Body Models from a Single Image using Deep Learning
   - RIS-aided Dual-Functional Radar and Communications Beamforming Design
3. Proposal
   - On Dual-Functional Radar and Communications Design with Reconfigurable Intelligent Surface

Education background

Education

Beijing University of Posts and Telecommunications[1] 2016 – 2020

BEng Telecommunications Engineering with Management

Queen Mary University of London[1] 2016 – 2020

BEng Telecommunications Engineering with Management, First Class Honours

Imperial College London 2020 – 2021

MSc Communications and Signal Processing

1. A joint programme of BUPT and QMUL

Awards

Main Awards

- Outstanding Final Project Paper of BUPT (Top 2%)
- Outstanding Graduate of BUPT (Top 5%)
- Outstanding Graduate of Beijing (Top 2%)
- First Prize of BUPT Innovation and Entrepreneurship Project (Top 3%)
- College Prize of QMUL (Top 3%)

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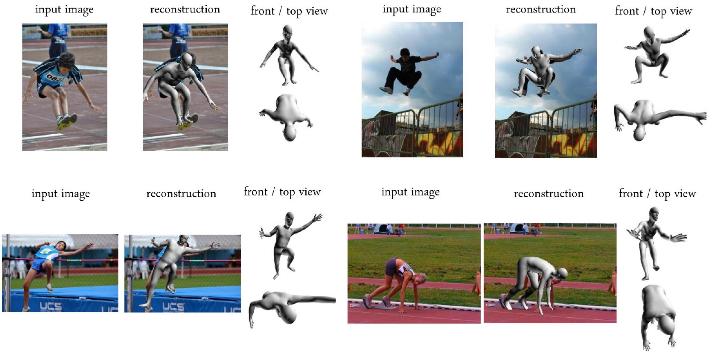
Estimate High-fidelity 3D Human Body Models from a Single Image using Deep Learning

What

An end-to-end framework that can estimate 3D mesh of the human body from a single RGB image.



Estimate High-fidelity 3D Human Body Models from a Single Image using Deep Learning

Why

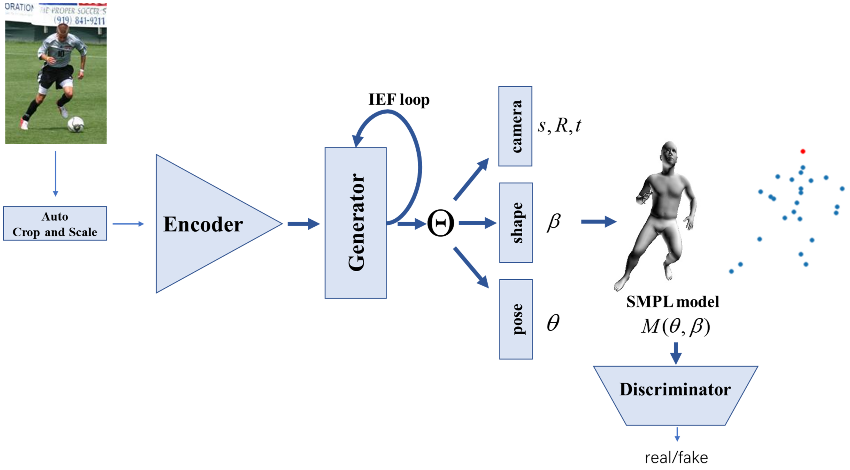
- Many existing methods only estimate 3D joints or skeletons (pose), but ignore the 3D shape;
- Many existing methods have multiple stages leading to a loss of information;
- The lack of in-the-wile images with ground truth 3D annotations.

How

- Apply a skinned multi-person linear (SMPL) model [1] to catch up both 3D pose and shape;
- Develop an end-to-end network;
- Train the network with a Generative Adversarial Network (GAN) [2];
- Train the network in an iterative error feedback manner (IEF) [3].

Estimate High-fidelity 3D Human Body Models from a Single Image using Deep Learning

- Framework



Estimate High-fidelity 3D Human Body Models from a Single Image using Deep Learning

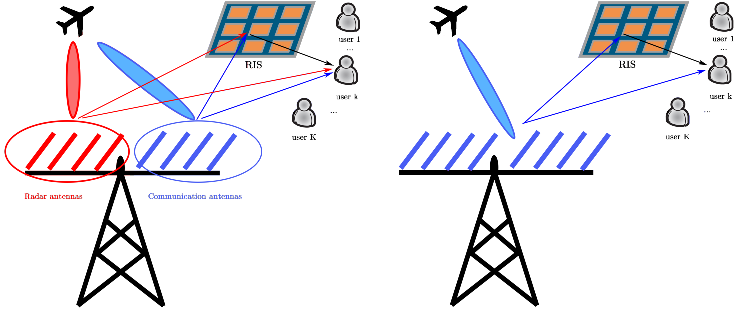
Conclusion

- With GAN, the overall network can be trained without the in-the-wild images with ground truth 3D annotations, but can still perform well on in-the-wild image.
- The training of this network only needs the in-the-wild images with ground truth 2D annotations. Thus, it is easier to improve in the future.
- As the network is end-to-end, the 3D model can be generated fast or even in real time.

RIS-aided Dual-Functional Radar and Communications Beamforming Design

What

An integrated radar and communication system that can simultaneously track a target and serve multiple communication users. A reconfigurable intelligent surface is deployed to improve the system performance.



RIS-aided Dual-Functional Radar and Communications Beamforming Design

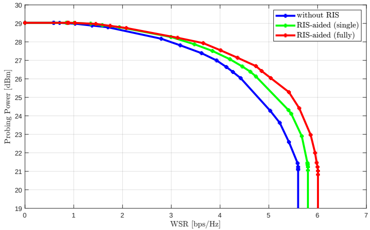
Why

- To solve the spectrum congestion problem of radar and communication system;
- To investigate the benefit of RIS in DFRC system;
- Weighted Sum Rate (WSR) maximization has not been studied in RIS-aided DFRC system [4, 5, 6].

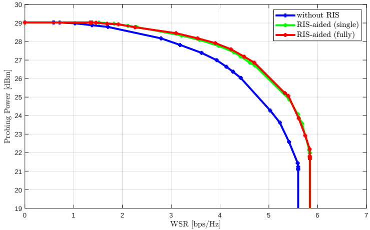
How

- Jointly design the active and passive beamforming to maximize the WSR and probing power;
- Apply a novel group or fully connected RIS model [7];
- Simulate the system in both Rayleigh and Rician fading channels.

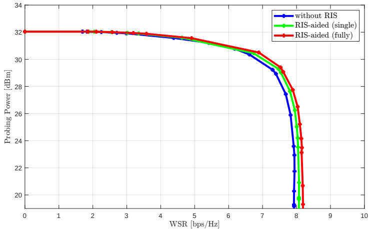
RIS-aided Dual-Functional Radar and Communications Beamforming Design



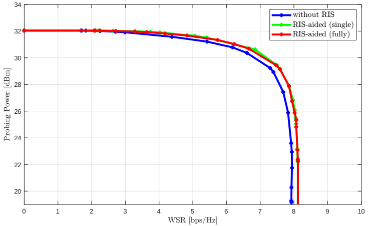
(a) Separated: Rayleigh channel



(b) Separated: LOS channel



(c) Shared: Rayleigh channel



(d) Shared: LOS channel

RIS-aided Dual-Functional Radar and Communications Beamforming Design

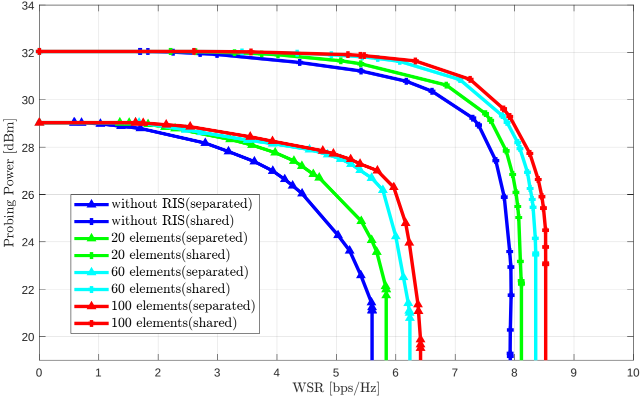


Figure: Effect of the number of reflecting elements

Conclusion

- RIS is capable of enlarge the achievable region of WSR and probing power.
- The fully connected RIS is more powerful than the single connected in Rayleigh channel, but not in LOS channel.
- More gain can be obtained by increasing the reflecting elements.

Limitation

- RIS is only used to improve the communication channel.
- The algorithm for the fully connected RIS converges slow. More efficient algorithm need to be found.

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On Dual-Functional Radar and Communications Design with Reconfigurable Intelligent Surface

Motivations

- To investigate the benefits of RIS is different system models.
- To explore the optimization of conventional radar metrics.
- To design more efficient algorithms for RIS-aided DFRC system (try deep learning?).

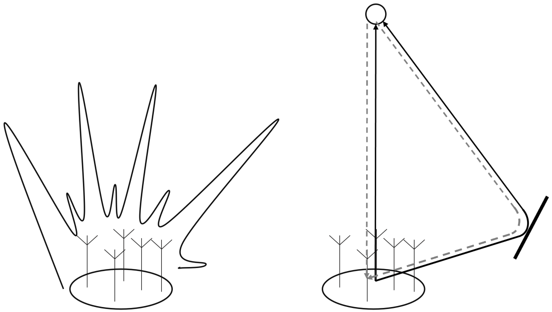
Literatures

- Maximize the detection probability under users' SINR constraints in RIS-aided RCC system [4]
- Maximize the SINR of radar echo signal under users' SINR constraints in RIS-aided DFRC system [5]
- Minimize the multi-user interference while approximate desired beampattern in RIS-aided DFRC system [6]

On Dual-Functional Radar and Communications Design with Reconfigurable Intelligent Surface

No-RIS DFRC vs RIS-aided DFRC

- In No-RIS DFRC, radar metric is usually approximating a desired beampattern [8, 9, 10]. But we can achieve more if the echo signals are considered in RIS-aided DFRC.



Beampattern
No gain from RIS

Echo signals

On Dual-Functional Radar and Communications Design with Reconfigurable Intelligent Surface

Conventional radar metrics

- Detection: detection probability P_D and false-alarm probability P_{FA}
- Estimation: mean square error

Example

According to [4], when the generalized likelihood ratio test under the Neyman-Pearson criterion is applied, the detection probability is given as

$$P_D = 1 - \mathfrak{F}_{\mathcal{X}_2^2(\rho)}\left(\mathfrak{F}_{\mathcal{X}_2^2}^{-1}(1 - P_{FA})\right) \tag{1}$$

If the radar signal is orthogonal, i.e., $\mathbf{R_r} = P_R \mathbf{I}_{N_t}$, and the echo signal is $\mathbf{y} = \beta \mathbf{C} \mathbf{r} + \mathbf{z}$, the parameter ρ is

$$\rho = |\beta|^2 P_R \mathrm{Tr}\left(\mathbf{C}\mathbf{C}^H \mathbf{R}_\mathbf{z}^{-1}\right) \geq \mathrm{SINR}_{\mathrm{echo}} \tag{2}$$

On Dual-Functional Radar and Communications Design with Reconfigurable Intelligent Surface

Potential benefits of deep learning

- Deep learning may catch up more information than conventional optimization method.
- Deep learning algorithm may have lower complexity.

A simple idea

Deep reinforcement learning: we can set the detection probability and WSR as reward, and the model will learn what is the optimal beamforming (actions) in different environments (states).

References I

[1] Federica Bogo et al. "Keep it SMPL: Automatic estimation of 3D human pose and shape from a single image". In: *European conference on computer vision*. Springer. 2016, pp. 561–578.

[2] Mehdi Mirza and Simon Osindero. "Conditional generative adversarial nets". In: *arXiv preprint arXiv:1411.1784* (2014).

[3] Joao Carreira et al. "Human pose estimation with iterative error feedback". In: *Proceedings of the IEEE conference on computer vision and pattern recognition*. 2016, pp. 4733–4742.

[4] Xinyi Wang et al. "RIS-assisted spectrum sharing between MIMO radar and MU-MISO communication systems". In: *IEEE Wireless Communications Letters* 10.3 (2020), pp. 594–598.

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[5] Zheng-Ming Jiang et al. "Intelligent Reflecting Surface Aided Dual-Function Radar and Communication System". In: *IEEE Systems Journal* (2021), pp. 1–12. DOI: 10.1109/JSYST.2021.3057400.

[6] Xinyi Wang et al. "Joint Waveform Design and Passive Beamforming for RIS-Assisted Dual-functional Radar-Communication System". In: *IEEE Transactions on Vehicular Technology* (2021).

[7] Shanpu Shen, Bruno Clerckx, and Ross Murch. "Modeling and Architecture Design of Intelligent Reflecting Surfaces using Scattering Parameter Network Analysis". In: *arXiv preprint arXiv:2011.11362* (2020).

[8] Fan Liu et al. "Simultaneous target detection and multi-user communications enabled by joint beamforming". In: *2018 IEEE Radar Conference (RadarConf18)*. IEEE, 2018, p. 89.

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[9] Xiang Liu et al. "Joint transmit beamforming for multiuser MIMO communications and MIMO radar". In: *IEEE Transactions on Signal Processing* 68 (2020), pp. 3929–3944.

[10] Chengcheng Xu, Bruno Clerckx, and Jianyun Zhang. "Multi-Antenna Joint Radar and Communications: Precoder Optimization and Weighted Sum-Rate vs Probing Power Tradeoff". In: *IEEE Access* 8 (2020), pp. 173974–173982.

Thank you