[1-minute talk]

Hello,

My name is Josiah Smith. I’m a researcher at the University of Texas at Dallas working to push the boundaries of imaging devices and deep learning. Today, I’m going to show you the strides we have been making in uniting mmWave imagers, deep learning, and computer vision algorithms to make music.

In this work, we demonstrate the viability of mmWave sensors for acute hand gesture tracking by constructing a novel musical interface using non-contact gesture tracking to control musical output. To accomplish this goal, our approach extracts high-fidelity spatial and temporal features of the musician’s hand from the radar return signal. We present a novel super-resolution technique using fully connected neural networks to improve localization. Further, we introduce a novel particle filter algorithm based on spatial and temporal corroboration to increase tracking performance.

If you want to learn more about this innovation in human-computer interaction, or just hear the radar musical instrument for yourself, please attend my 5-minute talk.

[5-minute talk]

Hello,

My name is Josiah Smith. I’m a researcher at the University of Texas at Dallas working to push the boundaries of imaging devices and deep learning. Today, I’m going to show you the strides we have been making in uniting mmWave imagers, deep learning, and computer vision algorithms to make music.

In this presentation, I’m going to guide you through the innerworkings of the Radar Musical Instrument and show you a demo of the instrument being played along with a song.

The FMCW radar regime offers several key strengths to precise position and motion sensing. Namely, the feature richness of the radar return signal. High resolution spatial and temporal signatures embedded in the radar beat signal enable robust non-contact human computer interaction offering promising solutions to a host of sensing applications even beyond the scope of musical interfaces.

The goal of this work is to design a non-contact musical interface using commercially available sensors to demonstrate the viability of mmWave sensors for acute gesture tracking.

To accomplish this objective, we develop a real-time spatiotemporal signal processing chain utilizing novel machine learning and computer vision algorithms to extract spatial and temporal features of the musician’s hand from the radar beat signal.

First, we develop a mapping scheme to assign musical meaning to spatial and temporal characteristics of the artist’s hand position and movement.

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To control the pitch, the musician moves their hand vertical above the radar selecting the note from a discrete set of user-defined notes.

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The user can oscillate their hand left and right in the cross-range dimension to control a vibrato parameter in the musical instrument.

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Lastly, the velocity of the hand is extracted from the Doppler frequency and used as a MIDI input to control any parameter in the virtual instrument as the user desires.

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Precise control of these musical parameters requires highly accurate spatiotemporal feature extraction and tracking. Here, we have simulated a point target in sinusoidal motion. However, added noise degrades the image and subsequent cross-range position. To solve this problem, we implement a fully convolutional neural network for image enhancement and super-resolution localization. The network is trained on real and simulated data to learn the device and ambient noise in addition to the irregular near-field beam pattern. After enhancement by the FCNN the image on the right is highly resolved, drastically improving localization and reducing the effect of noise and clutter on the Doppler spectrum.

However, even with the enhancement FCNN, the localization results across time are inconsistent.

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To improve the tracking performance, a modified particle filter algorithm is implemented based on a semi-stationary assumption and motion/Doppler corroboration. Now, the position is tracked consistently and smoothly as each measurement estimate is weighted based on its level of corroboration with the target’s Doppler velocity.

Pairing spatiotemporal signal processing algorithms, the enhancement FCNN, and the modified particle filter algorithm enables robust real-time tracking of the musician’s gestures and demonstrates the proficiency of mmWave technology for real-time acute hand gesture tracking.

Now

I know you joined this meeting hoping to hear some real radar-controlled music.

So, without further ado, I present, for your auditory pleasure, the Radar Musical Instrument controlling a MIDI virtual synthesizer.

[Next slide]

The Radar Musical Instrument leverages the strengths of mmWave imaging systems along with high-fidelity spatiotemporal signal processing algorithms and novel computer vision algorithms to create a high-resolution multi-application spatiotemporal sensing solution.

My name is Josiah Smith and I want to thank you for attending this presentation.