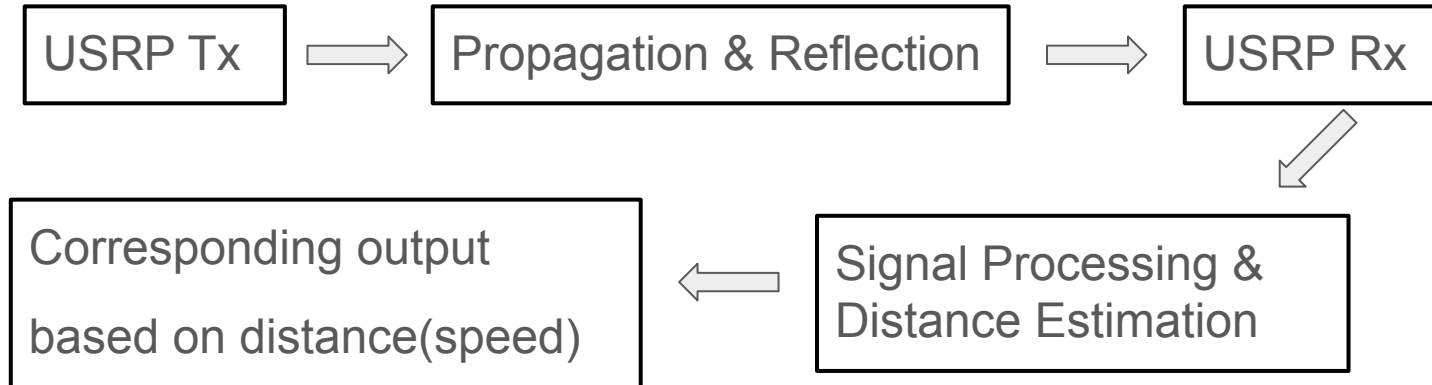# Final Project Proposal

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Selected topic

Short-Range Radar Distance Estimation and Interactive Control Using USRP and Horn Antennas

System Block

```
┌──────────┐      ┌──────────────────────┐      ┌──────────┐
│ USRP Tx  │ ==>  │ Propagation & Reflection │ ==>  │ USRP Rx  │
└──────────┘      └──────────────────────┘      └──────────┘
```

┌─────────────────────────┐   ┌─────────────────────────┐
│ Corresponding output   │ <== │ Signal Processing &   │
│ based on distance(speed) │   │ Distance Estimation   │
└─────────────────────────┘   └─────────────────────────┘

Basic Goal

1. **Measure the distance(interval) accurately** using the USRP radar setup

2. **Generate corresponding tones on the PC** based on the detected distance (distance-to-tone mapping)

Stretch Goal

1. **Support multiple reflective objects** so that more than one distance can be sensed simultaneously, enabling **chord playing**.

2. **Use hand motion speed as an additional control signal**, allowing actions such as **mode switching** when fast movements or shaking are detected.

Target experiment

1. Accuracy of Distance Measurement

- Place the reflector **at multiple fixed distances** (intervals determined during testing).

- Compare estimated distance with ground truth and evaluate measurement error.

2. Dynamic Tracking

- Move the reflector **continuously** during measurement.

- Plot **distance vs. time** to assess smoothness and stability of tracking
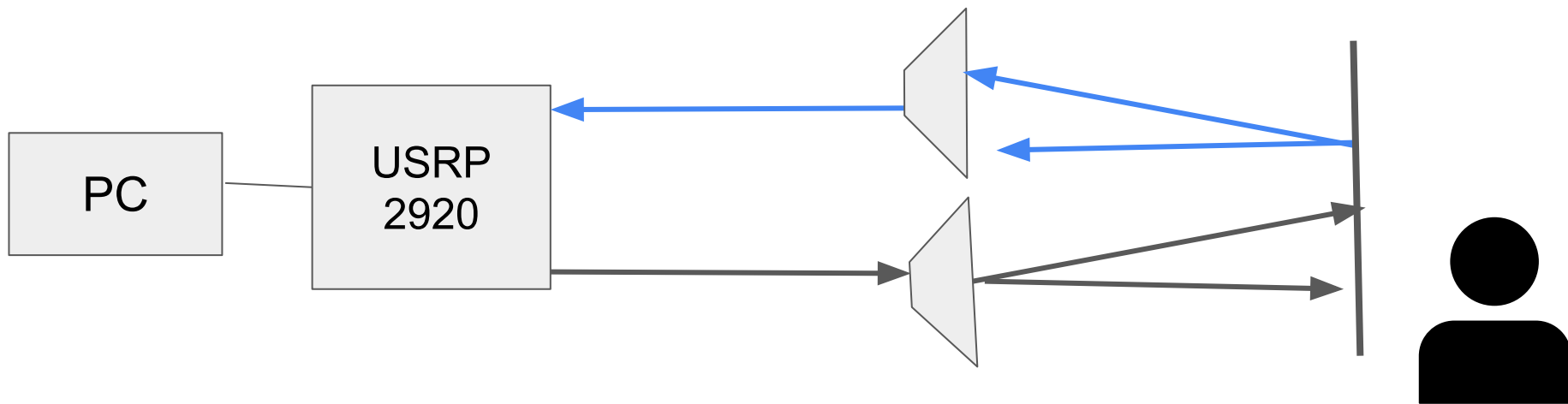
3. Gesture Detection (Bonus)

- Perform fast hand motions vs. normal playing.

- Check if Velocity-based rule detects gestures correctly to ensure gestures don't interfere with note output.

Requirement

Hardware: USRP2920*1、號角天線*2、反射面(鋁片) *n

Software:

- GNU radio: A development toolkit that provides signal processing blocks to implement software radios. It can be used with external RF hardware to create software-defined radios.
- Matlab

Reference

- https://www.youtube.com/watch?v=-NffMj4H3D0
- https://www.mathworks.com/help/wireless-testbench/ug/radar-target-emulation-on-ni-usrp-radio.html#d126e13556
- https://ieeexplore.ieee.org/document/10655128
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