South Carolina

ZigZagCam: Pushing the Limits of Hand-held MmWave Imaging

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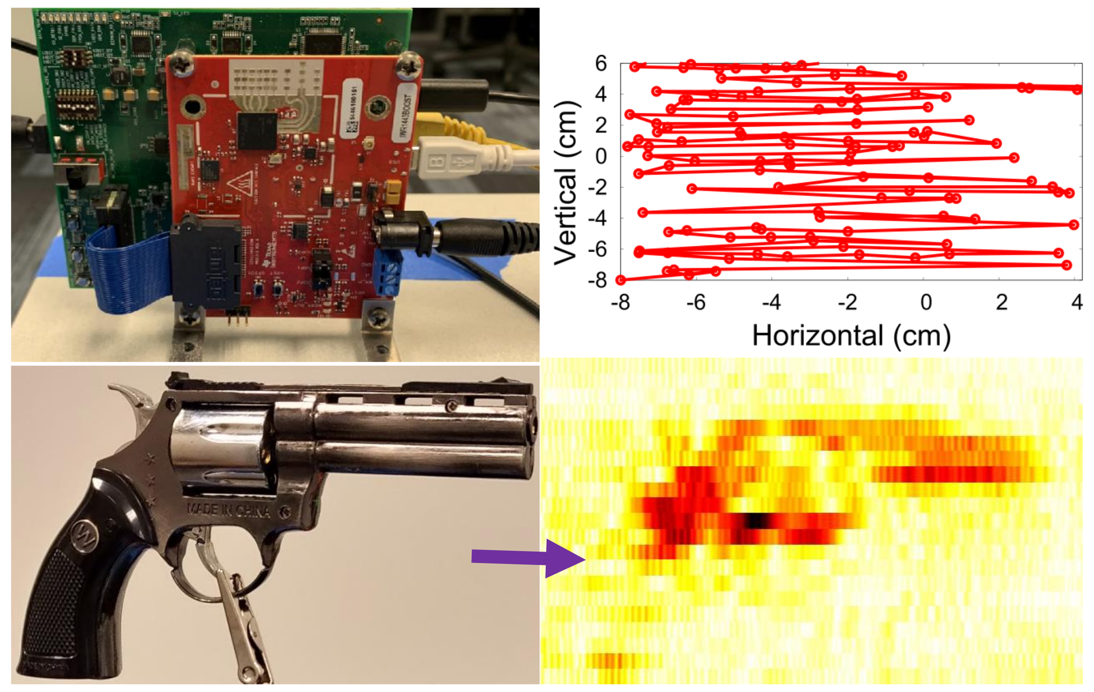
ZigZagCam: Objective & Challenges

Objective

- Bring **hand-held mmWave imaging** which gives **human perceptible 2D shapes, 3D orientation** for objects, even in **out of line-of-sight**

Challenge 1 – Imaging Issues

- Samples from **manual scanning** do not fall under uniform, ideal grid points
- There is **localized sparsity** due to non-uniform scanning



Challenge 2 – Specularity of Object

- **Specular reflectivity** due to improper orientation of object *w.r.t* scan plane
- Specularity only allows for a **partial human imperceptible shape reconstruction**

Motion Error Correction & Sparse Sample Recovery

Motion Error Correction

- The back-scattered samples are deviated away from the linear grid. A **phase correction factor**:

$$\Phi = \exp(jk2(d_u - d_s))$$

is multiplied to the deviated samples to estimate the equivalent samples on the closest point in the linear grid

Sparse Sample Recovery

- The **localized sparsity** in measurements does not allow all samples to be estimated from motion error correction. A **Compressed Sensing (CS) algorithm** is exploited to estimate the missing samples

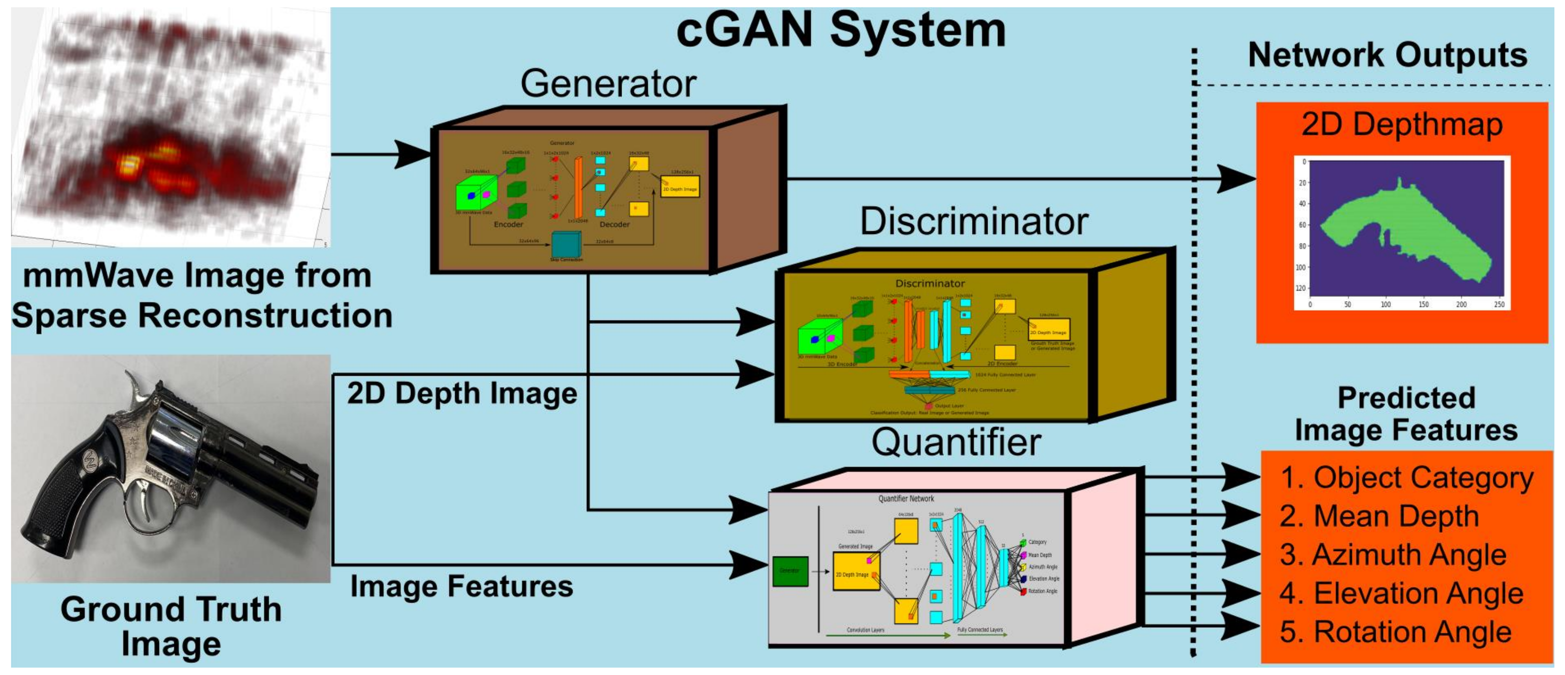
Reconstruction using Machine Learning

Recovering human perceptible 2D shapes using cGAN

- Conditional Generative Adversarial Networks (cGAN) uses **Generator** and **Discriminator** with **Custom Loss Function** to train Generator
- Post Training, Generator takes 3D mmWave heatmap and generates **2D shape**

3D Features with Quantifier

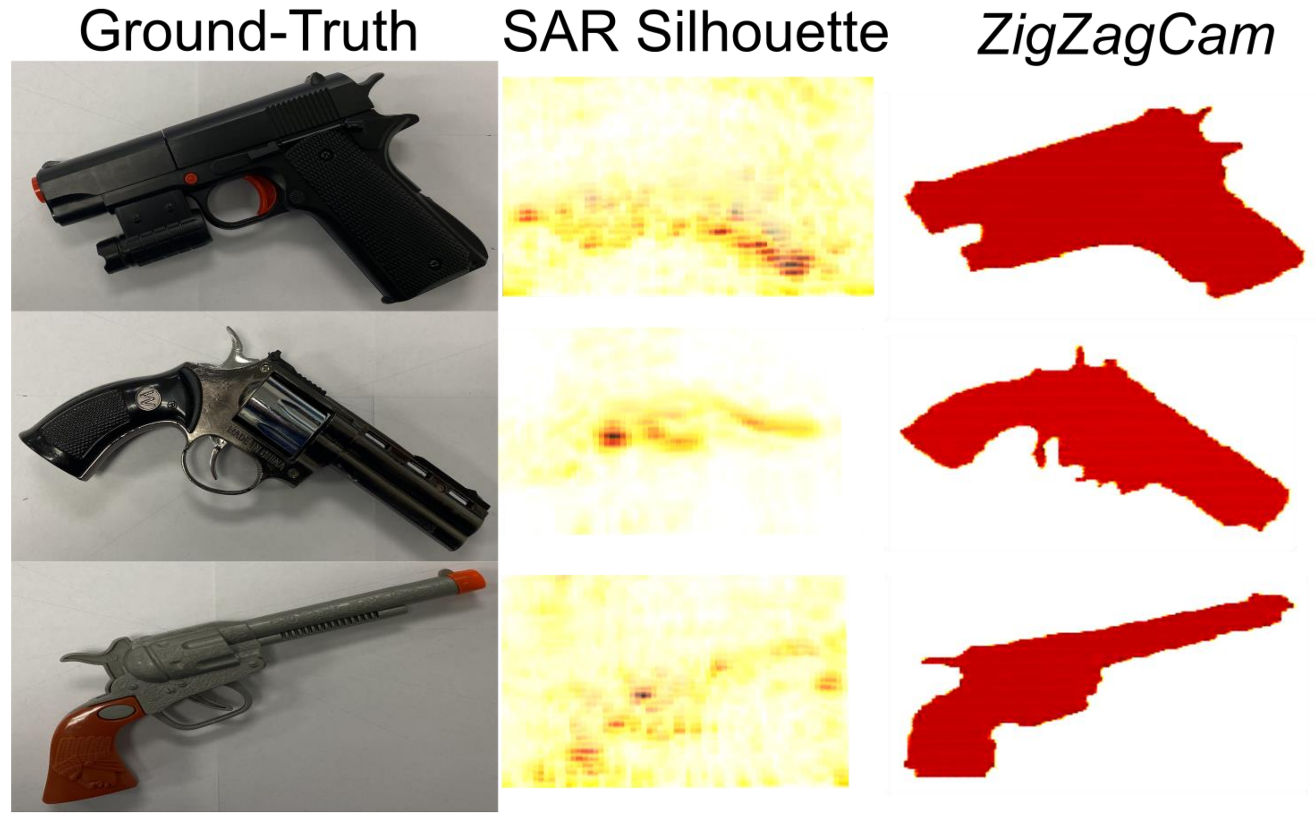
- Quantifier uses 2D shape to compute **Depth** and **Orientation**
- Orientation includes **Rotation, Azimuth, and Elevation angles**



Preliminary Results and Conclusion

2D Shape Reconstruction

- Rough **silhouette** from motion error correction and sparse recovery
- 3D mmWave test samples were fed to **Generator,** to get **2D shapes**
- More than **90% similarity score to ground-truth shapes**



3D Features Prediction

- less than **5% error for 90th percentile** of data for **Quantifier**

Conclusion and Future Works

- *ZigZagCam* brings **imaging functionality** to mmWave enabled **mobile devices**
- Machine Learning allows precise reconstruction of **2D shape** and **3D features**