TARGET CLASSIFICATION OF EXPERIMENTALLY-ACQUIRED LOW-FREQUENCY BACKSCATTERING COEFFICIENTS BY CONSTRUCTION OF SUBSPACES

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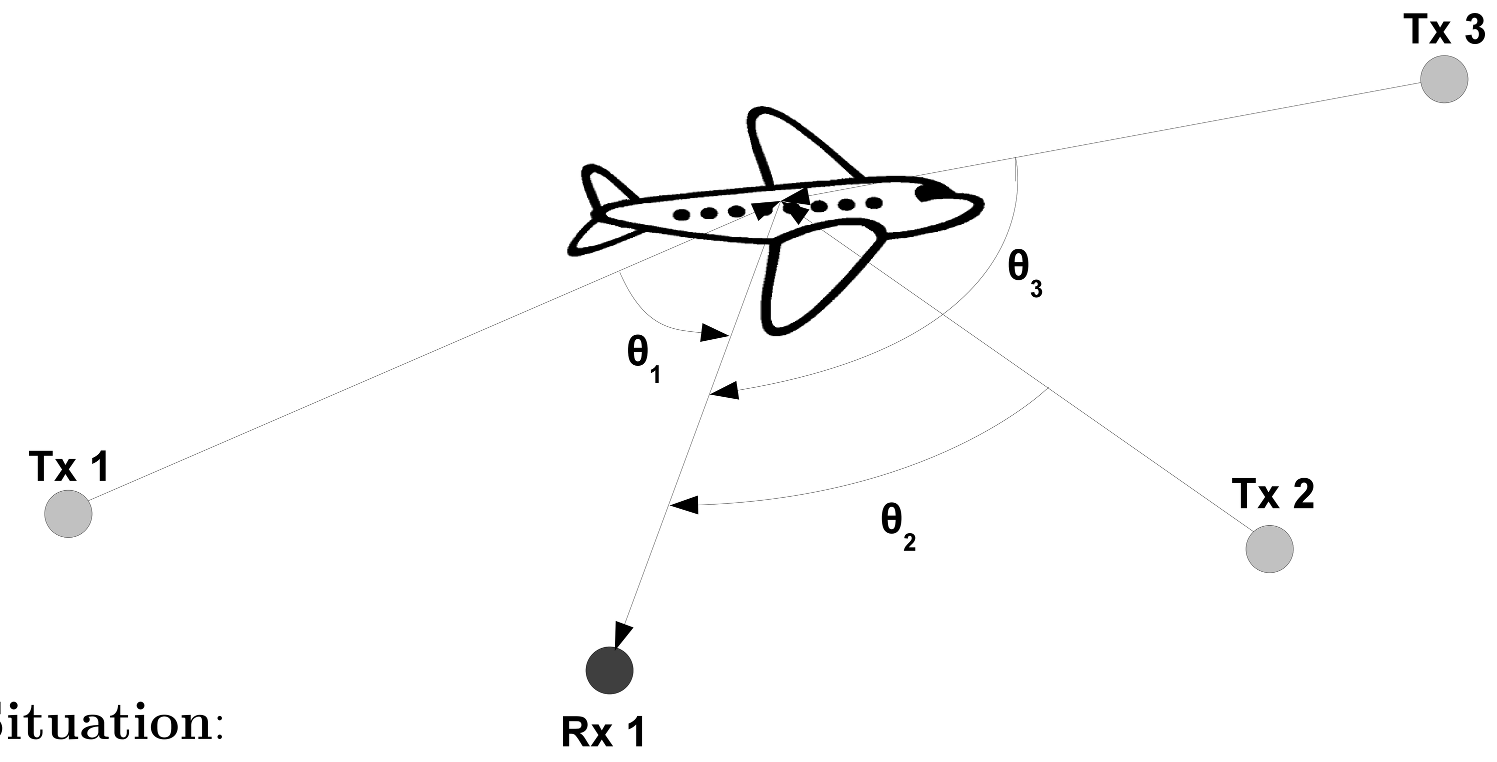
CONTEXT

- Goal: Automatic recognition of flying targets based on data collected by sensor
- Usually, data = reconstructed images of targets
- Here, recognition system is based on complex backscattering coefficients of targets



Situation:

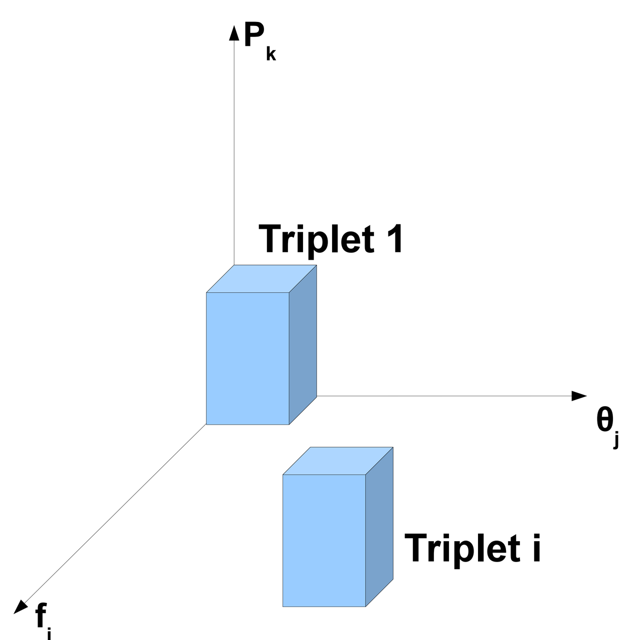
- Various emitters and 1 receiver
- 3 frequency bands f_i at Tx: $190-250$ MHz, $450-550$ MHz, and $1.2-1.3$ GHz
- 2 polarizations P_k at Tx: H or V
- 6 angular sectors θ_j for Tx-Target-Rx: from 1° to 160°, per step of 25°
- 2 classes: missile-like targets, and planes-like targets: analog silhouettes $\rightarrow$ difficult to classify because of same geometric profile

CONSTRUCTION OF SUBSPACES

- Data divided according to $\{f_i, \theta_j, P_k\}$
- For each $\{f_i, \theta_j, P_k\}$, 1 subspace per class $\rightarrow 3*6*2*2 = 72$ subspaces
- Subspaces built according to Singular Value Decomposition [1]:

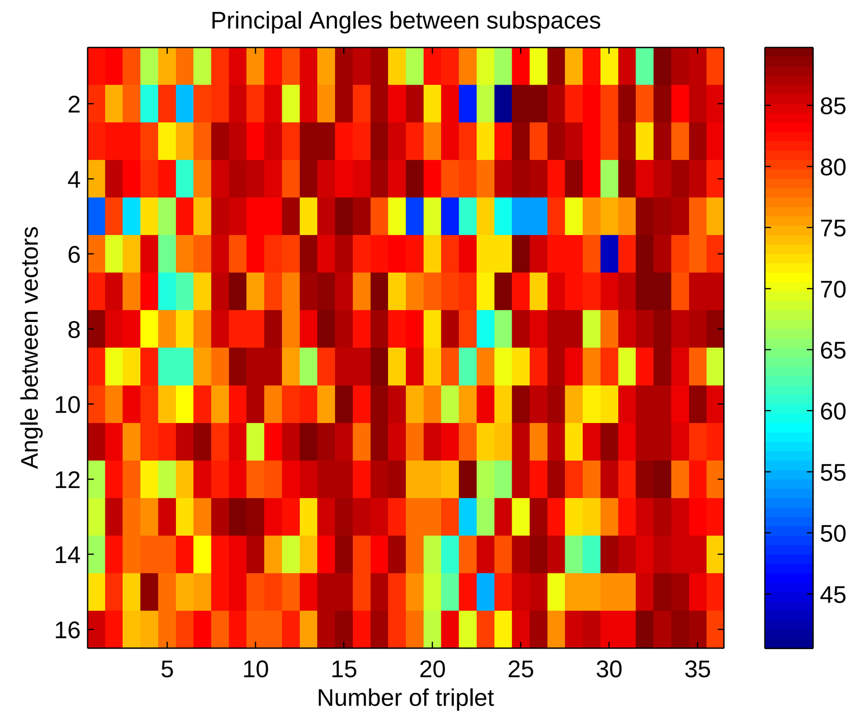
$$H = U\Lambda V^H \tag{1}$$

- 4 singular values Λ and singular vectors U per subspace



PRINCIPAL ANGLES [2]

- Angles vary between 40° and 90° $\rightarrow$ subspaces well separated
- 4 singular vectors per subspace, and 2 classes per triplet $\rightarrow 4^2$ angles per triplet (y-coordinate)
- 36 triplets $\{f_i, \theta_j, P_k\}$ (x-coordinate)



CLASSIFICATION [2]

- Triplet $\{f_i, \theta_j, P_k\}$ known for each input data
- Projector of each input data vector z computed for each subspace (1 per class):

$$P_z = UU^H \tag{2}$$

- Energy of projection computed E_z, for each subspace:

$$E_z = z^H P_z z \tag{3}$$

- Percentage of energy computed, for each subspace:

$$PercE_z = E_z / z^H z \tag{4}$$

- Class C_z assigned to z according to highest $PercE_z$ among 1 specific triplet
- Data to classify recorded in bistatic anechoic chamber
- Classification rate: 95% for missile-like targets, 75% for plane-like targets.
- Overall classification rate: 83.5%

CONCLUSIONS

Future work include:

- Use of oblique projection
- More efficient selection of subspace dimension
- More accurate class definition
- Combination of different emitters

References

[1] L. Scharf and C. Demeure, *Statistical Signal Processing: detection, estimation, and time series analysis.* Addison-Wesley Reading, MA, 1991.

[2] R. Behrens, L. Scharf, C. Inc, and C. Broomfield, "Signal processing applications of oblique projection operators," *IEEE Transactions on Signal Processing*, vol. 42, no. 6, pp. 1413–1424, 1994.