<table>
<tr><td>TITLE :</td><td>Gesture Recognition for Smart Home Applications using Portable Radar Sensors</td><td>YEAR
2014</td></tr>
<tr><td colspan="2">KEY CONTRIBUTION</td><td>THEORY</td></tr>
<tr><td colspan="2">human gesture recognition system based on pattern recognition of signatures from a portable smart radar sensor.</td><td>analyzed the feature space using principal components and application-specific time and frequency domain features extracted from radar signals for two different sets of gestures</td></tr>
<tr><td colspan="3">DEPENDENT VARIABLES</td></tr>
<tr><td colspan="3">● classification accuracy for 11 different motion classification combinations
● 3NN 10-fold cross validation results using top 20 features extracted based on PCA
● The accuracy rate from I and Q magnitude difference feature when training the kNN model</td></tr>
<tr><td colspan="3">INDEPENDENT (AND HYPOTHESES)</td></tr>
<tr><td colspan="3">● Generate a single-tone -3 dBm carrier signal at a frequency of 2.4 GHz AC-coupled CW mode portable radar sensor is used to in this work to sense different gestures
● The radar sensor was placed 1m above ground, the distance between the radar and the person was in the range of 2 meters.
● radar I and Q signals
● classifier used was K-Nearest Neighbors with k=3
● sampled four familiar motions (no movement, shaking head, nodding and hand lifting) from the same person with 20 repetitions for each motion resulting in a sample set of 80 samples with four categories
● micro-Doppler information obtained by applying Short-Time Fourier Transform (STFT) to the output I/Q signals with a sliding window size of 2.56 second (512 samples)
● Hamming window was used</td></tr>
<tr><td colspan="2">METHODS</td><td>ANALYSIS</td></tr>
<tr><td colspan="2">● The received signal is captured, amplified, digitizes and transmits them to a laptop through an USB port.
● feature extraction based on Principal Component Analysis (PCA) that maps the signals into orthogonal components with highest variance.</td><td>● Considered feature extraction based on capturing physical attributes such as relative direction and speed of motion during the duration of gesture
● supervised learning kNN model
● accuracy was calculated using 10 fold cross validation
● I and Q magnitude difference features to trained the kNN mode
● Doppler shift for complex gesture</td></tr>
<tr><td colspan="3">FINDINGS</td></tr>
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- **The accuracy is highest (90%) for categorizing shaking head and nodding movements but average classification accuracy stays low at 64%**
- **PCA may not be suitable to extract the most discriminative features from input radar signals**
- **The accuracy rates are all > 92% and 100% for some of the classification combinations from the two magnitude difference features**
- **The performance of Magnitude Difference actually dropped since the PCA features still remained significant in the model formation process.**
- **if the user performs more complicated gestures, the accuracy of our recognition system will be limited**
- **The differentiability between shaking head and hand lifting is still quite distinct, but there are overlapping points between hand pushing and hand lifting.**
- **recognition system has been substantially improved by adding Doppler features**
- **It outperforms both PCA based kNN and magnitude difference based kNN and produces an average 10 fold cross validation classification rate of 98%**

FUTURE RECOMMENDATION/GAP	REMARKS	Learn gesture recognition using radar
For future research, we will consider a significantly higher number of gestures and optimal placement of radars to improve the robustness and accuracy of the recognition system along with detailed comparison with state of the art gesture recognition systems.		