2D-Multiple Signal Processing Approach to Human Orientation Monitoring Using Millimeter-wave FMCW Radar

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Abstract

In recent years, unobtrusive continuous monitoring devices have been subjects of research interest. These sensors enable remote monitoring of human vital signs and activity levels, which can be used in an expensive list of applications including the detection of distracted driving, gait analysis, and fall detection - applications that are highly dependent on information regarding the posture of the subject under test. In this work, a method of human posture orientation estimation is proposed using a high frequency mmwave (millimeter-wave) Frequency-Modulated Continuous Wave (FMCW) radar.

1 Introduction

Recent years have seen burgeoning interest in the field of non-invasive sensors for a variety of applications, particularly with the use of FMCW radars, which allow for safe measurements with high range resolution. While work has been done on the discrimination between large posture differences [1], they are highly subjective to the direction the target is facing, which is an issue that is seldom explored.

In this work, a 2D-MUltiple SIgnal Classification (MUSIC) based point-cloud generation algorithm is proposed. The method is then used to generate point-clouds of human subjects in a seated position in 2 orientations - facing the sensor and facing away from the sensor. The results of the algorithm are visually distinct and can be used as inputs into a classifier for the automated classification of posture orientation.

2 Method

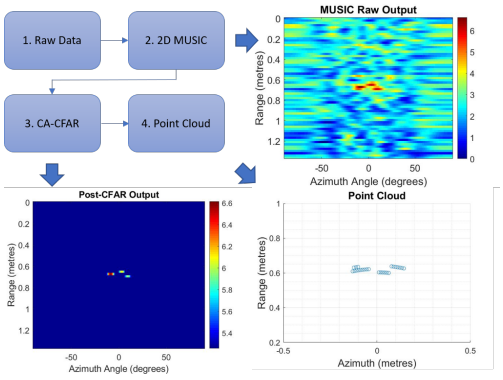
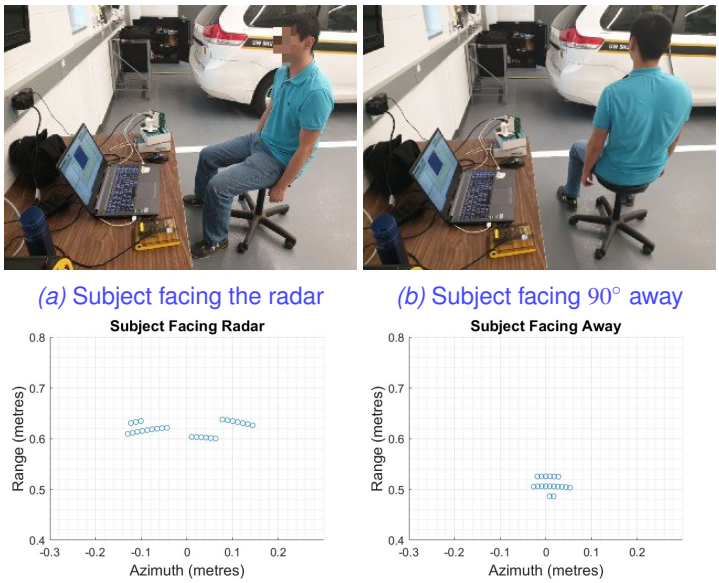


Fig. 1: Processing chain employed for point-cloud generation

The targets are first extracted from the raw data using a 2D-MUSIC algorithm [2]. Subsequently, the output passed through a CA-CFAR filter to identify targets within the plots, which identifies targets using an adaptive threshold and sets values below the threshold to 0. Then, point-cloud plot showing the profile of detected targets is produced using the CA-CFAR output.

3 Experiment Setup and Results

Experiments were conducted with 3 human subjects to assess the ability of the algorithm to detect human targets and accurately generate their body profile in the form of a point cloud.



(a) Subject facing the radar *(b)* Subject facing 90° away

(c) Point-Cloud of subject facing radar *(d)* Point-Cloud of subject facing away from radar

Fig. 2: Measurement setup and generate point-clouds

Measurements were taken of individual subjects seated in different positions - facing the radar and 90° away from the radar with the center of the torso of the subject located 60cm away. The point-cloud plots generated from the above and the measurement setup are shown in Fig. 2.

When the side-profile of the subjects are measured, the point-cloud cluster is much narrower, attributed to the narrower profile of the body from the perspective of the radar. The cluster is also 10cm closer to the radar, which corroborates the change in orientation of the subject since its shoulder is closer to the radar as compared to the torso. The point-cloud plots of all 3 subjects are also similar, showing that the method is consistent and reliable in obtaining results from different subjects.

From the resulting point-cloud of the plots, it is evident that the profiles of the test subjects are distinctly different and can be clearly discriminated from each other.

4 Conclusion

A 2D-MUSIC based point-cloud generation method for the estimation of human posture and orientation was proposed, producing visually discernible plots of human subjects facing and facing away from the radar. In a future work, the method can be expanded into a 3D form and subjects can be seated off-centre from the radar to determine the effectiveness of the method under more conditions.

The development of such a technique is potentially influential in the building of radar sensors for applications such as automatic fall detection, gait analysis and prevention of distracted driving.

5 Acknowledgment

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References

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[2] Manokhin, G. O., et al, "MUSIC-based algorithm for range-azimuth FMCW radar data processing without estimating number of targets. doi: 10.1109/mms.2015.7375471