Demo: Indoor Positioning via 24GHz Radio Frequency

Wei Yang, Yishen Han, Weigao Chen, Rui Li, Zhiping Jiang
School of Computer Science and Technology, Xidian University, China
xdgodyw@gmail.com, mail@weigao.cc, {*rli, zpj*}@xidian.edu.cn

Abstract

Multi-targets indoor positioning is of great importance to many real applications, and attracts many efforts commit on this issue. Most passive indoor positioning systems rely on commercial off-the-shelf products to build inexpensive systems, and already have a relative high accuracy. In order to make it pragmatic to large space indoor positioning applications (over 10 km^2 area), those existing ways may face lack of effective transmission distance, since most devices are short of transmission power. We design and implement a 24GHz FMCW (Frequency-Modulated Continuous Wave) radar prototype to support multi-targets positioning, and can be applied in many scenarios.

According to different aims of each scenario, the prototype can auto adjust different signal processing algorithms to guarantee the detection accuracy. This radar prototype is a K band radar system operating on 24GHz using FMCW scheme. Through the built-in ARM processor, it can detect moving targets in *cm* level with high accuracy and extremely low false alarms.

1 Introduction

FMCW radar is a special type of radar sensor which radiates continuous transmission power like a simple continuous wave radar. In contrast to this CW radar, FMCW radar can change its operating frequency during the measurement, that the transmission signal is modulated in frequency or in phase [2].

When the prototype works, the signal modulator will produce a certain modulation signal waveform into the VCO (Voltage-controlled oscillator) input, and produce a certain range of FM signal, that is, FM continuous wave. Then, through the power amplification and antenna the signal is sent. When the signal encounters the target, a portion of the energy will be reflected back and received by the receiving antenna. In the period of time when the electromagnetic signal travels between the antenna and the target, the frequency of the transmitted signal has changed compared to the echo signal returning to the receiver. At this point the echo signal is amplified and mixing with local oscillator signal, we can get the difference frequency signal. The difference frequency signal contains information such as target distance and speed. Therefore, we use signal processing algorithms to deal with the difference frequency signal, and further get target line-of-sight (LOS) distance, target azimuth and other related information. Many sensing applications using mmWave to track gestures or other people changes [1]. However, we could achieves a LOS tracking distance up to 500 *m*. The detection angle can be as wide as 90 degrees, and the resolution can reach 0.25 *cm*. This is the basic principle of how our prototype system works.

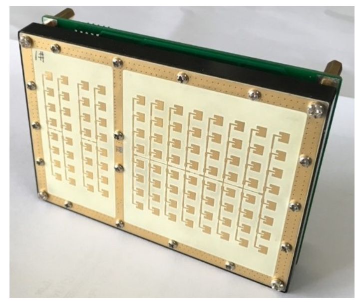
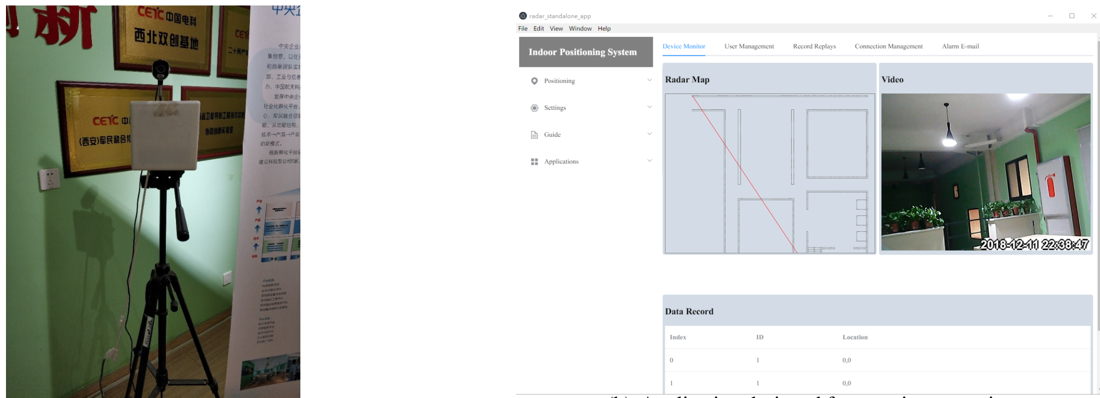


Figure 1. 24GHz FMCW radar prototype with 1Tx and 2Rx antenna arrays.

Figure 2. Digital signal processing board and radio frequency detection part of the prototype.

International Conference on Embedded Wireless Systems and Networks (EWSN) 2019
25–27 February, Beijing, China

ISBN: 978-0-9949886-3-8



(a) Radar deployment in real scenario (b) Application designed for security protection

Figure 3. Experimental Setup with our prototype, and it is a packaged device with wave-transmitting material. We develop and implement a tailored software to show the real-time positioning status of multi-targets.

2 Key Technologies

We use our radar prototype to track various targets, and during the positioning period, the background could be stationary or slowly moving objects. The signals reflected or scattered by these two types of background are noise signals for target positioning. Therefore, we use digital signal processing algorithm to deal with the noise. There are three main stages of our signal processing approach: MTI (Moving Target Indication), MTD (Moving Target Detection) and CFAR (Constant False-Alarm Rate).

In the first stage, MTI uses the Doppler effect of the moving target to distinguish between the moving target and the fixed target. In the second stage, the main task of MTD is to detect the moving target from the fixed noise. The basic principle of this stage is based on the difference in spectrum to distinguish the moving target and the fixed target. In order to achieve the purpose of suppressing the clutter of the fixed target and to detect the moving target, it is also possible to obtain a rough estimate of the target velocity in this stage. In the last stage, the CFAR method is to change the fixed threshold to an adaptive variable threshold, and the size can be adjusted adaptively according to the noise of the detected point, the background of the clutter and the size of the interference.

3 Applications and Further Directions

3.1 Multi-target Positioning and Tracking

The prototype can positioning and tracking multiple objects in large indoor situations, such as in warehouses and shopping malls. Extract useful signals from the whole signals to distinct how many targets are in the covered area and even figure out the micro movement of a certain target.

3.2 Security Monitoring and Perimeter Guard

This system is designed for specific places need to monitoring people with privacy protection. The system also can be applied in shopping malls and other large building around to prevent suspicious actions or any security monitoring for invasion.

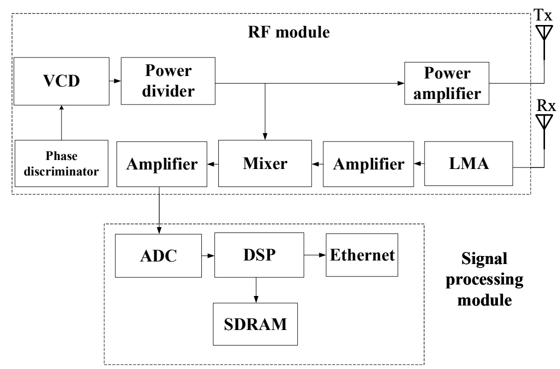


Figure 4. Architecture design overview of our FMCW radar prototype

3.3 Further Directions

We need to modify the digital signal processing algorithm to improve the accuracy and restrain the false alarms. We consider to elevate the operating frequency to 77GHz. When the working frequency elevated, we could get higher modulated bandwidth. Therefore, we could get higher resolution through improvement of the DSP processing ability. According to FMCW radar principle, we know that the radar resolution is mainly depend on modulation period, bandwidth, and frequency resolution.

4 Acknowledgments

This work is supported by National Natural Science Foundation of China (No.61502374, No.61802291), China Postdoctoral Science Foundation (No.BX20180235), and Research Funds for the Central Universities (No.JB171003)

5 References

[1] Z. Li, Z. Yang, C. Song, C. Li, Z. Peng, and W. Xu. E-eye: Hidden electronics recognition through mmwave nonlinear effects. In *Proceedings of the 16th ACM Conference on Embedded Networked Sensor Systems*, pages 68–81. ACM, 2018.

[2] H. Liu, H. Darabi, P. Banerjee, and J. Liu. Survey of wireless indoor positioning techniques and systems. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)*, 37(6):1067–1080, 2007.