ECE 445

SENIOR DESIGN LABORATORY

PROJECT PROPOSAL

A mmWave Breath Monitoring System for Smart Vehicle Applications

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Team #20

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1 Introduction

1.1 Problem

Forgetting children in a hot car has always been a problem needed to be solved since 21th centuries. According to data statistics, more than 900 children have died in hot cars since 1998 and more than half of them were left behind unknowingly by their caregivers. When this accident occurs, people would blame on their parents for their carelessness. However, David Diamond, PhD, a professor of psychology at the University of South Florida in Tampa pointed out that left children in a car is not a negligence problem but a memory problem and it could happen to everyone [1]. Therefore, this problem will still exist in the future and device helping caregivers to detect children in the car is urgently required. We hope to design a system to detect the breath of children staying in the car and gives alarm to their parents as soon as possible if they forget them in the car.

1.2 Solution

These years, radar technique has been developing swiftly and it gradually turns from the military field to civilian field such as applications for aircraft, ships and automobiles [2][3]. This project aims to design a system using mm-wave radar and radar signal processing method to detect children's breath in the car. For the basic principle of breath detection system using radar, our radar will transmit periodic linearly-increasing frequency chirps known as Frequency-Modulated Continuous Wave (FMCW) towards the object. In order to measure small scale vibrations such as breathing, we will measure the change in phase of the FMCW signal with time at the object range bin and it can be derived by taking the FFT of the beat signal. In practical, our team decide to use TI-60GHz mm-wave radar development board IWR6843ISK-ODS and CP210 driver to finish the hardware link and data collection. Data collected will be then sent to the software Matlab for the application of millimeter wave radar range detection and micro-doppler detection. To be specific, after generating the FFT graph in Matlab, we will use peak detection algorithm to judge the possible objects and the phase time domain graph should be analyzed to select the starting point of breathing and determine the breathing rate. With the breathing rate we calculate from Matlab, we will do further signal processing and improve our algorithm to detect the children's breath in complex and diverse environments. Finally, we plan to design a UI to allow user to know the breathing status of children in the car.

1.3 Visual Aid

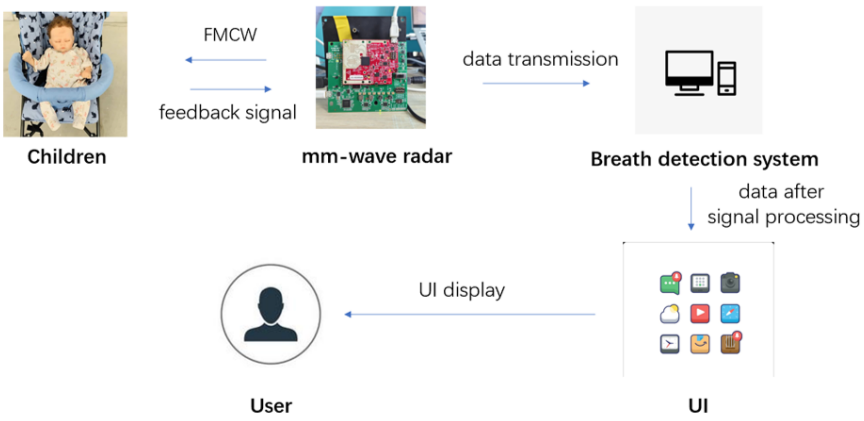

Figure 1: Visual Aid.

1.4 High-level requirements list

1. Since we care more about younger children such as babies when stuck in the car, so our system should manage to distinguish the respiratory waveform of children for different ages.
2. In different weather, children may wear various clothes which may have some influence on detection, our system should be able to work well under the circumstance of different shielding materials.
3. In a car, children may stay in different postures and it could be a factor affecting the detection result. Our system needs to detect children's breath under different postures.
4. Sometimes, there will be more than one kid in the car and we hope our system to be capable of detecting multiple persons.

2 Design

2.1 Block Diagram

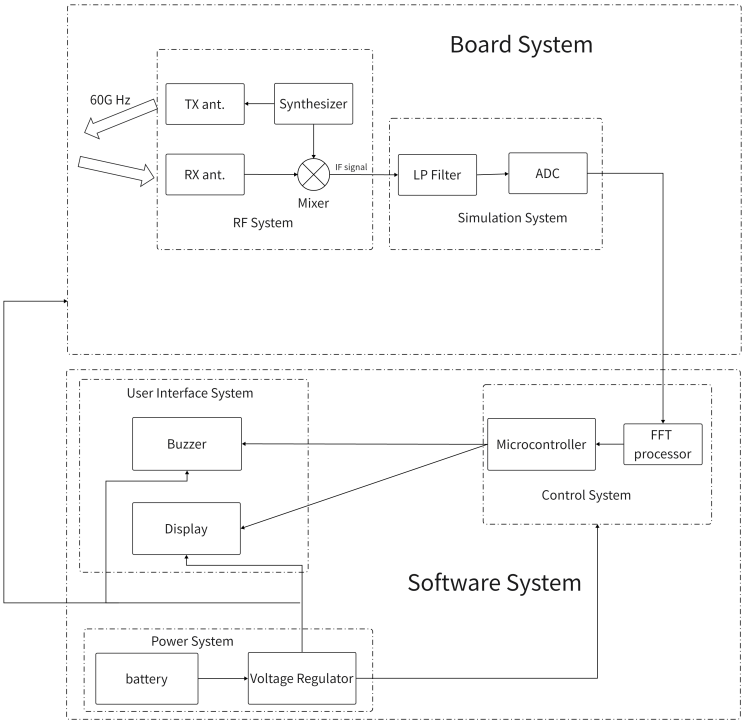

Figure 2: Block Diagram.

2.2 Subsystem Overview

RF system: TI-60GHz mmWave Radar Development board: IWR6843ISK-ODS. A sensor to work on Millimeter wave radar range detection and micro-doppler detection technology.

Simulation system: Digitize the signal, the ADC can support the IF bandwidth of S2dmax/c.

Control system: Do the FFT to do radar signal processing and self-detection technology in complex and diverse environments.

User interface system: Visualize the result from the processor and show the result on the display. We plan to use a buzzer to show the result as well.

Power system: generate proper voltage to supply those systems.

2.3 Subsystem Requirements

2.3.1 RF system

It consists of three components: Mixer, synthesizer and Antenna. The synthesizer generates a chirp and pass the chirp to mixer and TX antenna. TX antenna transmit the chirp to environment. And RX antenna receive the delayed vison of this chirp. The mixer is used to mix the original chip and delayed chirp to get IF signal.

2.3.2 Simulation system

The IF signal consist of multiple tones, the frequency of each tone being proportional to the distance of the corresponding object. So this system use LP filter to filter the noise and ADC to convert the IF signal to analog digital signal. And ADC must support an IF bandwidth of S2d/c. It is connected with the Control system with the transmission line.

2.3.3 Control system

it consists of two parts: FFT processor and Microcontroller. The FFT is performed on the ADC data. The location of peaks in the frequency spectrum directly correspond to the range of objects. After that, we get the signal which tells the microcontroller to turn on the buzzer or not. The microcontroller receive the data represents the breathing and distance of objects and can control the buzzer and display screen.

2.3.4 User interface system

it receives the signal from the control system. And Display screen can show the data whether there are people breathing in the car or not. If there are people, for example the children, in the car, the buzzer will start to ring and give the warning signal. Otherwise, the buzzer will not ring.

2.3.5 Power system:

it is connected with all other subsystems and generate proper voltage to those systems.

2.4 Tolerance Analysis

1. The unwanted air flow is one thing that will influence the precision of the detection. The human breath is relatively weak comparing with body movements and other moving objects. 2. The different shielding materials is also a factor which must be taken into consideration. 3. The Breath Monitoring system may need to detect multi-person case.

3 Ethics and Safety

3.1 Ethics

According to [4], we promise to uphold the highest standards of integrity, responsible behavior, and ethical conduct in professional activities. To be more specific, we will ensure all data is from legal source and all our actions including data collection and data management won't cause any harm to any people or group. Also, we will ensure the privacy of all data and volunteers.

Further more, according to [4], we promise to treat all persons fairly and with respect, to not engage in harassment or discrimination, and to avoid injuring others. To be more specific, we will treat every people fairly regardless of their racial, age, social status, etc. And we will respect all their intention and protect their safety.

3.2 Safety

We will use 60GHz mmWave Radar. Unlike much higher frequency ultraviolet, X-ray, and gamma radiation, mmWave radiation is non-ionizing because the photon energy is not nearly sufficient to remove an electron from an atom or a molecule, so it is less harmful. Thus, the main safety concern is heating of the eyes and skin caused by the absorption of mmWave energy in the human body. Searching the potential biological effects of mmWave radiation on the human body, [5] supposes that our bodies are reflective and do not absorb much mmWave radiation. Though the eyes are particularly vulnerable to mmWave radiation-induced heating, [6] supposed that it won't cause detectable ocular damage being exposed to such mmWave radiation even for a long time. So under our careful instruction, the data collection process won't cause harm to volunteers.

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