3D Face Recognition from RGB Camera and Radar Sensor

Stergious Aji

School of Computing Science
Sir Alwyn Williams Building
University of Glasgow
G12 8QQ

MSci Interim Report

November 19, 2023

Contents

1 Introduction

1.1 Motivation

Facial Recognition is a crucial area of research for its wide range of applications spanning security surveillance, forensics, human-computer interaction and healthcare. Its most popular application being access control using biometric authentication. This removes the need to remember passwords and provides a non-invasive, hands-free approach to human verification. Facial metrics are naturally more accessible in comparison to other biometrics like fingerprint, iris or palm print.

Facial recognition systems have come a long way since its dawn in the 1960s. The earliest work by Bledsoe [2] distinguished faces by comparing distances of manually annotated landmark features such as the nose, eyes, ears and mouth. In more recent years, the advent of Deep Learning techniques has greatly improved face recognition performance with help of the sheer number of images of faces online. However, these systems primarily rely on 2D imagery from RGB cameras which are vulnerable to lighting changes and pose variations. To compensate for this, depth information of facial attributes are required. Additionally, moving to 3D facial recognition increases the security of biometric authentication systems.

3D face recognition systems are becoming more popular with the likes of many smartphone companies integrating a type of face unlock such as Apple's Face ID [1]. Furthermore, this demand has pushed this depth sensing technology to smaller form factors and requiring little power and computation to work efficiently on mobile devices on the fly.

Most depth cameras used for this purpose use a form of active face acquisition where non-visible light is emitted and reflected back from a person's face which is subsequently captured by sensors and measured to estimate facial features. The most popular approach uses LiDAR which emit waves in the near-infrared spectrum. The main disadvantage to this is that it is usually too weak to penetrate clothing or hair. In contrast, millimetre waves used in Radar can penetrate thin objects to directly reach the dermal layer of the skin meaning that it may perform better against occlusion like obstacles or even rain or fog.

Very little research has been done in the effectiveness of using Radar waves for 3D face recognition but what has been done show positive results [](CITE). Radar technology is often less expensive in terms of acquisition cost and computational cost since it requires little energy to power compared to LiDAR cameras. However, Radar has its drawbacks since it is less accurate and sparse which may hinder its performance for facial recognition. A solution is to combine RGB information with the depth captured by the Radar sensors to effectively learn facial features and identify them.

1.2 Aims

This project aims to investigate the effectiveness of using RGB cameras in conjunction with mmWave Radar sensors for 3D facial recognition. Since there are no easily accessible datasets online for this purpose, we will require acquiring this data ourselves. We will be using an Intel RealSense L515 [4] camera to capture the RGB information of a subject's face. The Google Soli Radar sensor [](CITE) will be used to capture depth information from reflected millimetre waves.

This RealSense camera also includes a LiDAR sensor which produces a more accurate dense depth image. As a backup, a separate model can be trained to transform the sparse Soli data into a more dense representation before inputting into the facial recognition model. However, if the Radar data works well this may not be needed. (MAY NOT INCLUDE)

Since data must be collected we aim to collect faces of around 50 participants which will be enough to train and evaluate our proposed model given the tight timeframe. We aim to acquire face data of different poses, lighting conditions and with multiple occlusion scenarios.

Next we aim to produce our very own face recognition model using a Deep Concurrent Neural Network to learn facial features using both the RGB and depth information acquired from the Soli sensor. We will investigate different data fusion techniques in order to find the best approach to combine RGB features with the Radar data.

2 Background Survey

Before any work is conducted, a review of relevant literature in the field is conducted in order to corroborate best practices and gain a deeper understanding of the strengths and weaknesses of using a Radar sensor, specifically for face identification. Firstly, a look into the datasets available for our purpose and the subsequent reasoning behind the requirement to gather our own dataset will be explored. This section also provides recent study of using machine learning techniques to classify radar signatures of human faces.

2.1 Radar Technology

Radio Detection and Ranging, or Radar, technology has been around for decades and is used in many important applications such as space exploration, military and commercial aircraft and ship navigation, as well as, weather forecasting. However, only recently with the miniaturisation of Radar sensors to the millimetre wave (mmWave) spectrum has research expanded to other small scale domains [](CITE). Most notably, Google integrated their own Soli sensor for face detection and motion gesture recognition into their Pixel 4 smartphone [](CITE). Furthermore, mmWave sensing is being explored in the domain of autonomous

driving for instance, the application of collision warning and adaptive cruise control systems [3]. mmWaves offer an advantage over the traditional near-infrared waves used by Light Detection and Ranging (Lidar) cameras, with its robustness to atmospheric conditions such as dust, smoke, fog and rain as well as extreme lighting conditions [](CITE).

2.2 Data Acquisition

2.3 Multimodality of Data

2.4 Data Fusion Techniques

2.5 Deep Learning for Face Recognition

3 Proposed Approach

state how you propose to solve the software development problem. Show that your proposed approach is feasible, but identify any risks.

4 Work Plan

show how you plan to organize your work, identifying intermediate deliverables and dates.

References

[1] APPLE INC. About Face ID advanced technology, 2023. Accessed: 2023-11-19.

[2] BLEDSOE, W. W. The model method in facial recognition. *Panoramic Research Inc., Palo Alto, CA, Rep. PR1 15*, 47 (1966), 2.

[3] DF ROBOT. Eight Practical Applications of mmWave Radar Technology, 2023. Accessed: 2023-11-19.

[4] INTEL CORPORATION. Intel RealSense LiDAR Camera L515, 2023. Accessed: 2023-11-19.