Supporting personnel in warehouses with an inertial measurement unit

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Abstract

Your abstract here.

Contents

List of Acronyms and Abbreviations

This document requires readers to be familiar with terms and concepts described in RFC 1235 [**?**]. For clarity we summarize some of these terms and give a short description of them before presenting them in next sections.

IMU	Inertial Measurement Unit
RFID	Radio-Frequency Identification

1 Introduction

In the past, several companies introduced certain devices to track motions of their employees and goods in warehouses in order to support employees there. Due to high labor cost, it is crucial that picking items is efficient [1]. These are either dedicated devices, using different ways to operate (e.g. wristbands using ultrasonic or voice-assisted technology [2]. Amazon wants to measure arm movements and eventually give haptic feedback to the worker. This creates technological challenges to be precise enough with a low error rate. However, it raises ethical questions. For instance, will employers abuse their tracking capabilities to put pressure on employees, or track during breaks or other private activities?

Problem statement Wristband solutions mentioned in the previous section are either not dedicated to supporting activities in warehouses, e.g. fitness wristbands, or have not been made commercially available [2]. Common warehouse management technologies, for instance, pick-by-voice, radio-frequency identification (RFID), or barcodes, support workers during their job [3]. However, workers still do mistakes which require post-correction or compensations implying a higher cost. Goods can lose traceability when wrongly placed. This decreases productivity and slows down the speed of delivery. By introducing tracking devices for employees, a number of side effects and ethical questions arise, such as: Can the employers abuse the information collected by the wristbands to put pressure on the employee?

Problem Employee errors that result in misplacing items in warehouses has a high cost for companies. Can wristbands be used to identify errors by humans when placing items?

1.1 Theoretical framework/literature study

”An inertial measurement unit (IMU) is a small and portable device that combines information obtained from multiple electromechanical sensors (e.g. accelerometers, gyroscopes, and magnetometers)”[4]. The usage of IMU to detect human body motion has been proofed by several studies in the past [4] [5] [6].

All IMU sensors are sourceless, meaning that they work independently. However, especially in small wearable devices, they are very noisy. [7]. A common method to reduce this noise is the Kalman filter [8]. It allows to reduce the impact of the noise by mathematical calculations. Kalman also provides a prediction feature to correct the gyroscope drift [9] [10].

1.2 Ethics and sustainability

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1.3 Research questions, hypotheses

We saw that several solutions exist for displacement tracking using ultrasonic sensors. We would like to experiment with an IMU and find out if it is capable of executing similar measurements.

Out hypothesis is that we can correctly decide whether an item had been placed inside the correct container or not. In this scenario we assume that the containers are around the size of 50-100 cm wide and long.

Hypothesis: Using an inertial measurement unit (IMU) would be precise enough to detect placement in a scenario where items need to be moved from one container to another.

Purpose: The project will investigate whether precise tracking of items is feasible and if it is achievable with easily accessible, low-cost sensors, such as accelerometer and gyroscope. Furthermore, we will analyze the ethical concerns regarding this problem and understand the social impact such a solution can have.

Goal(s) The goal is to conduct an experiment that accurately measures the placement of items between two containers with aid of IMU data. The data from the experiment should give us a clear understanding if an IMU is capable of fulfilling the needs. This result can be used to validate our hypothesis.

2 Method(s)

The method of this project is empirical prototyping. A regular smartphone will be used for the app. Simple software will run on the device that will analyze the sensor output data. Creating our own microprocessor (Arduino) device would require more time than is available during the course. We believe a smartphone is the best way to approach this problem as we already have such a device and it already contains the IMU and easy to write applications for this Android smartphone. In order to test the prototype, we will conduct experiments, rather than rely on simulations, e.g. an Android studio development environment. We rather ask users to move items between two containers. A potential setup is the following: placing two square boxes of tens of centimeters close to each other. Using the hand with the "wristband" (smartphone attached to wrist), the balls in one container are grabbed and moved to the other container one by one. Negative tests are done, too. (—— EXPLAIN THIS!!!! ——) The app will detect if the placement is correct or not. These experiments will be recorded (—- Will you make a video?? —-) and analyzed. Furthermore, publications will be analyzed in order to have a clear understanding of the current technologies used.

We implement our own software for Android operating system[11]. We use Android Studio [12] to implement our application and to deploy it to the mobile device. We decided to use Java programming language [13] for the implementation. Our test device is a Xiaomi Redmi Note 4 mobile phone [14] and its inbuilt measurement units. A second test device is a Motorola G5 Plus [15].

We implement an application according for the mentioned system. For this, we use already existing libraries on GitHub to avoid implementing complex algorithms such as a Kalman filter [16]. In our application we use two GitHub [17] projects. After collecting the sensor data, we use FSensor [18] to filter the data. This helps us filter out the noise and keep the useful data. This step is an important step as the raw data is very noisy. ——————————————————————————citation here if we can find something——————————————————————————. Then the acceleration data is integrated twice to get position and at this point another GitHub repository is used. It is the GraphView [19]. This provides a simple way to plot data on the phone screen. Using this method, the X and Y position data is displayed and the results can be seen. After starting the app, the tracking starts and automatically stops after a few seconds, concluding the results. This time is enough to perform the movement of placing the item from one container to another but short enough not to accumulate too much error increasing the accuracy of the final position.

3 Results and Analysis

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4 Discussion

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A Insensible Approximation

Note that the Appendix or Appendices are Optional.