

A Low-cost Delivery Notification and Protection System

Final project report for CSCI 6011 Introduction to Computer Systems (2021 Fall)

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Abstract—This report documents the development of a new anti-theft delivery protection and in-time notification system, which doesn't rely on what express company is delivering the package. This cost-efficient solution will free people from worrying about losing their parcels and at the same time decrease the delivery-theft cases in a larger sense.

Keywords—*delivery, anti-theft protection, in-time notification, Raspberry Pi, Arduino, Python*

I. INTRODUCTION

With the fast development of E-commercials and the rapid growth of express chains, people are shifting from buying things in-store to shopping everything online. However, one big difference of online shopping from offline shopping is that your bought items are shipped to you in packages, instead of getting them instantly. This leaves a period of your parcel standing outside of your home with no one is watching for it. This also leaves a chance for thieves to steal the parcels from your porch, and they hardly get caught due to lack of evidence. The package theft problem might be worse than you think. According to the study, 23 million Americans have had their packages stolen from their home before they could open them[1]. In another study, it was stated that from March to July in 2020, 1 in 5 Americans reported a stolen package[2]. To prevent the packages from being stolen, people are thinking of solutions, although there is no single way that can solve the problem perfectly. On the express companies' side, they are providing delivery notification services such as Amazon, but not every company does that. On our side, there are two main ways we can do: one is to set up a notification system which doesn't rely on the express company so that we can quickly take the parcel in when we get the signal, the other is to secure our package in a way that thieves cannot easily take it or we can trace it back. My project developed such a system for people to get in-time notification of the delivery and secure their package. The project used Raspberry Pi 4 as a central controller and an Arduino Uno with a force sensor as the detector. When the package is put on to a delivery box where the sensor is set up on the bottom of the box, the Arduino will send an HTTP request to the server running by Raspberry Pi, and the host will send an email notification with the picture of the parcel to the specified email address. When the package is taken, the detector will be triggered and the camera connected to the Raspberry Pi will take a picture of the person who takes the package, and the host will send an email again with the picture of the person's face. If the package is taken by a thief, you can report to the police with the picture you got from the system. The system is relatively cheap, requires little equipment and a simple setup and only uses minimum power and network data. The existence of the

protection system will expectedly scare off thieves who steal deliveries and help the police department solve cases of delivery thefts.

II. RELATED PROJECT WORKS

A. Delivery notification service provided by express companies

Amazon has a delivery notification service provided to customers who order products from and shipped by Amazon. However, the quality of the service is not consistent, which depends on the region where you live and the delivery person. Even with the notification service, the package is still not secured and cannot be traced if it is stolen. Thus, the notification-only system is not enough for delivery protection. Furthermore, not every company provides an in-time notification service, for example, USPS, DHL, FedEx, etc., which makes the customers hard to secure their deliveries.

B. Centralized locker boxes provided by the express company

Some express companies such as SF express in China provides centralized locker boxes. This seems like a good solution for apartment residents if the lockers are right inside their building. However, it is not efficient or reasonable to install locker boxes in every apartment for the express company. So there are many people who need to walk a long distance to get to fetch their packages from the locker boxes located at a centralized area for the surrounding buildings. Again, it is also not possible to have every company provide locker box services, and there is not much we can do on the customer's side. In less population-dense living areas, where people live in houses, it is more impossible to use centralized locker boxes for deliveries.

C. Outdoor security cameras

Third-party companies developed outdoor security cameras which can be set up around where the packages are typically delivered. The footage of the camera can be used as evidence to report theft if the package was stolen, but the camera is usually on the wall or on the ceiling, which is not facing directly to the person who steals the package. Although you can install the camera at the specified location for the deliveries, it is still not energy or data efficient for a camera running all day long and recording every piece of footage it catches. Of course, you can use a camera with a motion detection function, but the camera itself doesn't have notification functions.

D. Locker boxes for deliveries

There are kinds of commercial smart delivery boxes developed for delivery protection. First, the prices of such boxes are extremely high, a typical example is the lockable delivery box developed by DeliverySafe, which is priced at \$549.99. Second, such a box raises a problem for the delivery person, the owner must think of a way to let them know a simple way to get access to the box, otherwise, it is possible that the package will still be put outside of the box. Third, if someone wants to steal, they may probably just take the box as a whole.

E. Delivery notification system based on Raspberry Pi

This project is described in the book ‘Raspberry Pi Home Automation with Arduino’[3], which builds a system for delivery notification. However, the project in the book only sends out a notification when the package is delivered, while not securing the package. My project enhanced the functionality of the previous system, while improving the existing advantages.

III. SOLUTIONS/ANALYSES

To conclude the related projects mentioned above, there hasn’t been a comprehensive way of protecting and notifying deliveries. So I developed a system for delivery protection and in-time notification, which is carried out in this project.

A. Raspberry Pi as a central control

The device Raspberry Pi 4 is set up as a central control in this project. Because we need to send notifications when the package is delivered and when it is taken, the Raspberry Pi is doing the notifying part. I wrote a Python program to receive the HTTP request sent from the Arduino, and then it will have the connected cameras to take pictures and send emails to the specified email address. The reason why we are using Raspberry Pi as a central control is that it is adaptable and can extend its functionality with many accessories, and we can also set up more than one detector in our delivery notification system.

B. Arduino Uno as a detector and signal sender

The Arduino Uno is set up as a detector at the location where packages are delivered. A force sensor is wired to the Arduino to send digital-analog input in response to force. To make sure the package is always in the right spot where the sensor is set up, you can put the Arduino with the sensor in a delivery box, with the sensor in the center, and put a big sign outside of the box to remind the delivery person where to put the packages. A script written in C language is uploaded to the Arduino. The serial port monitors the analog input from the force sensor, when the analog input reaches the specified threshold, the Arduino will send an HTTP POST request to the Raspberry Pi, which will, later on, trigger the host to send out the notification email; when the analog input drops back below the threshold, the Arduino will send out another request to the Raspberry Pi, to trigger the host to capture a photo and send out a ‘delivery taken’ notification email.

C. A real-life situation for the use of this system

Suppose we have our system successfully set up in a house, where the Raspberry Pi and Arduino Uno are connected to the internet, and the detector is put in a delivery box on the porch. Situation 1: you are working remotely at

home, when the package is delivered, you get an email saying the package has been delivered within seconds, and you take your package inside without the risk of losing it. Situation 2: you are away from home, and your package is delivered, unfortunately someone stole your package, but you have got an email with the picture of the thief’s face, then you report it to the police and they arrest the thief and get your package back.

IV. SUMMARY AND FUTURE WORKS

In sum, I have developed a cheap and effective delivery protection and notification system. This project has many advantages compared with the existing solutions, including cost-efficient, energy-saving, networking data-saving, etc. Although this project was developed successfully and is working perfectly as expected, there are still many ways to improve it to make it a better system and more competitive in the market.

A. Multiple deliveries

The current system was designed to notify a single package if the force threshold is reached or touched. In the real-life, we always have more than one package delivered and they may not arrive at the same time. In that case, multiple delivery notifications might be necessary, and the protection notification may also be changed to take pictures and notify the owner as long as one of the packages is taken. To do this, we need to change the IF condition for sending HTTP requests from analog input reaching the threshold to analog input changes.

B. Alarm when taking away the parcel, while recognizing the owner

Inspired by museums and jewelry shops, we can add an alarm system for the project. When the package is taken, there will be an alarm ringing to scare off the thief, hopefully dropping off the package at the same time. However, we don’t want it to ring an alarm when we are taking the parcel ourselves. This also applies to our current system, since we don’t really want it to take pictures when we are taking the parcel away, although it’s not that a big deal. One possibility is to add a switch to turn the protection system on and off at any time, either a physical switch or a digital one. For example, we can add a button which is hidden somewhere in the delivery box, if we press it before we take the parcel, the alarm won’t ring when it is taken. An advanced solution might be, when the camera takes a picture of the person who takes the parcel, it compares with the picture of the owner and only proceeds with the protection system if it doesn’t recognize the person’s face, although this might be not so feasible when everyone is wearing a mask during the pandemic.

At last, there is no guaranteed way to prevent our packages from being stolen as long as there are thieves. We all hope the world will become better and better, and the day will come when everyone is free from worries about crimes.

Source code: Please refer to the attached text files.

REFERENCES

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