Smart Restocking and Quality Monitoring System

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KFUPM, Capstone 2.0: Senior Design Project Team 64

Introduction

Problem statement:

Retail shelves frequently deplete before staff can detect, resulting in customer frustration. Our system utilizes intelligent solutions to promptly alert employees of low stock levels, while our desktop application efficiently manages inventory and facilitates restocking requests. Moreover, an assistant button enhances customer satisfaction, optimizes staff deployment, and elevates service standards.

Background

Constraints:

- Cost Efficiency & Durability
- Sensor and Camera Performance
- Integration & Ease of Installation
- Ease of Use
- Maintenance
- Safety & Security

Target Specifications:

- Signal transmission between devices within 10 seconds.
- User-friendly program interface accessible within 7 clicks.
- Handheld device weight under 300 grams, and a screen size under 1 inch.
- Total loss for the computer vision model shall be under 10%.
- Ability to take images and send them to the Python server (CV model server) within a minute.

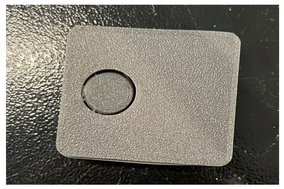


Figure 1. Assistant button

Figure 2. Camera Case

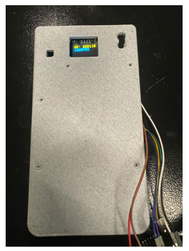


Figure 3. Handheld gadget

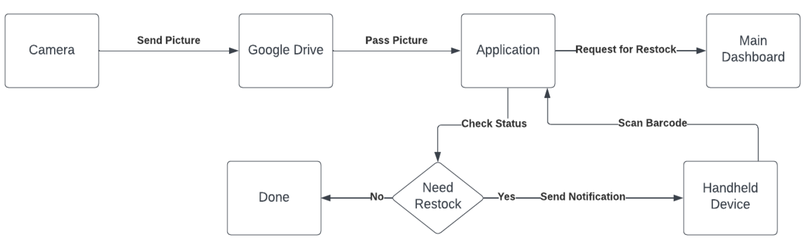


Figure 4. Detection Process chart

Project Impact

Our 'Smart Restocking and Quality Monitoring System' presents an answer to problems faced by the retail industry. Our solution ensures correct and timely replacement of shelves by streamlining restocking procedures using computer vision and advanced wireless connection. Our approach improves employee's time management and helps staff to focus on other activities. Our solution has the potential to enhance the retail industry, by improving inventory management and provide better client experiences, which will be beneficial to both companies and customers.

Prototype Design

Hardware:

- The handheld gadget: We used 3d printed material through the university faculty, to make cost-effective and lightweight.
- Assistant button: We used 3d printed material and integrated microcontrollers into it.
- Camera case: We used 3d printed material and integrated the ESP32Cam module.
- Stand: Carefully picked to simulate the situation of setting a camera on another shelf.
- Slider: Custom camera slider with 2020 aluminum shaft, and multiple bolts with 3d printed frame.
- Shelf: Used for demo purposes, so we outsourced it.

Software:

- An application with a computer vision model.

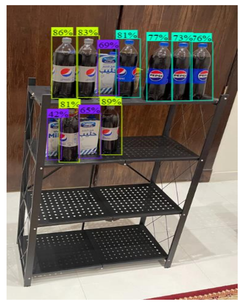
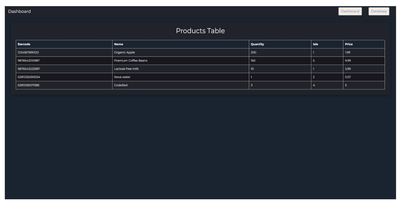


Figure 5. Computer vision detection.

Figure 6. Camera stand and slider



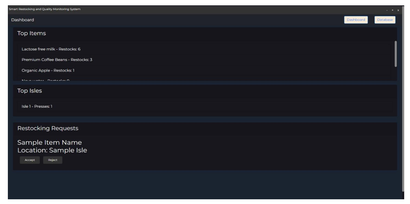


Figure 7. Application

Testing

- **Device signal transmission within 10 seconds**:
  We set a timer, and we send a signal from the handheld to the application
- **The handheld device weighed under 300 grams:**
  We weighed it.
- **Screen size under 1 inch:**
  We took the information from the manufacturer of part.
- **Ability to take images and send them to the Python server (CV model server) within a minute:**
  We set a timer and send an image from the cloud server to the Python script in our server
- **Total loss for the computer vision model shall be under 10%:**
  We got the results from the loss function.

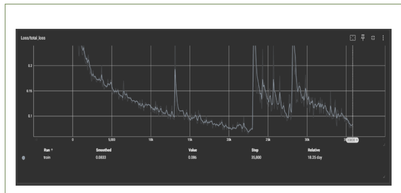


Figure 8. Model A total loss

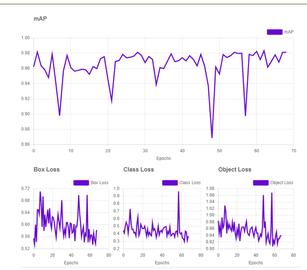


Figure 10. Model B metrics

```
Ignoring non-file-related change or missing data
New file detected: photo_2024-04-19_16-48-36 (1).jpg
Handle processing for new file: photo_2024-04-19_16-48-36 (1).jpg
Updated files list checked.
```

```
stdout: Done!

stdout: Downloading image from URL

stdout: {'milk': 1, 'diet pepsi': 1}
true
```

Figure 9. Image processing

Conclusions

In conclusion, the application of computer vision technology shows promise in addressing stock management challenges in retail settings, although it requires substantial investment in training the model. Our prototype demonstrates high accuracy and the ability to detect partially included items on the shelf but, with its limited items in the dataset, faces scalability issues in real-world retail environments with extensive item variety. Moreover, we designed devices to precise specifications, yet testing revealed misalignment due to inaccurate component descriptions. Manufacturing challenges include sourcing suitable screws, nuts, bearings, and belts. Despite our camera slider's effective performance, fine-tuning adjustments posed difficulties.