PACKAGE THEFT DETECTION ON WYZE CAMS

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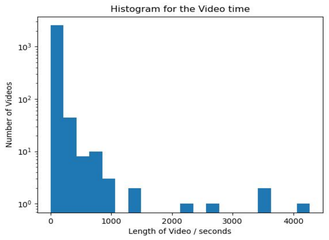
Project Introduction

Package theft is a problem that negatively impacts the public especially during a pandemic situation where the demand of online shopping and package delivery increase tremendously. This project aims to build a machine learning based software system which can identify the action of package theft and improve home security level for families and companies. The main deliverables of this project are a large scale package theft detection dataset and a machine learning system build upon that.

Dataset Collection and Annotation

- Balanced sampling mechanism is used to avoid dataset bias, such as package theft, normal delivery, normal pickup and irrelevant normal videos.
- In our dataset, videos are downloaded from public Internet sources, as well as recorded by our team members.
- Videos are annotated in the format of: video name, class category, starting and ending frame of package theft action.
- Breakdown of the Package Theft Detection Dataset:

Category	Normal video			Package theft video	Total
Sub-category	Irrelevant normal	Normal pick-up	Normal delivery	-	-
Number of video	500	85	500	1097	2182

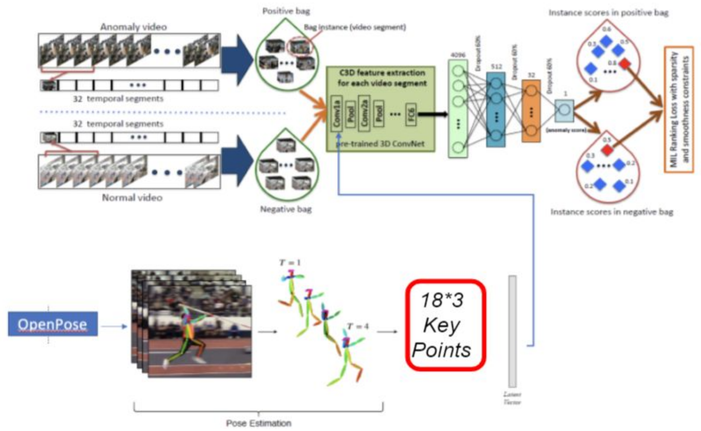


Machine Learning Models

- Two deep learning systems are used to build our package theft detection system.
  - Anomaly detection system is used to detect the package theft activities.
  - Human pose estimation system is integrated with the anomaly detection system to improve detection accuracy.

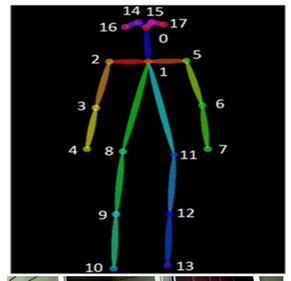
End-to-End Anomaly Detection Model

- As our main system, the anomaly detection model takes videos as inputs and generate anomaly scores for video segments, ranging from 0 to 1 (0 = normal, 1 = abnormal).[1]
- This model serves as the end-to-end solution for package theft detection.
- This model can leverage weakly-labelled training videos by using MIL ranking loss function with sparsity and smoothness constraints.
- After training this model with package theft and normal videos, it can generate high anomaly scores for package theft scenes but low anomaly scores for normal scenes.
- The image below is our pipeline. It is modified from the pipeline of [1] paper.



Human Pose Estimation Model

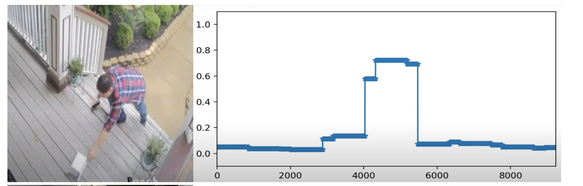
- Human pose estimation is the problem of localization of human joints in images or videos. We used OpenPose,[2] one of the most widely used estimator, as our tool.
- In each picture, or each frame in the video, OpenPose will provide us the human joints information in the format of 18 key points, along with the x, y coordinates and its confidence. The image to the right-top shows the index and human joints relations.[2]
- The image to the right-bottom shows how the OpenPose works on our video. Overall the ratio of human pose detected is about 60%. The accuracy will increase when people are closer to camera. The code we used is a pytorch version of OpenPose from [3].
- After getting the human pose information, we concatenate them to the end of the C3D feature from the video, and feed the integrated data into the anomaly detection neural network.

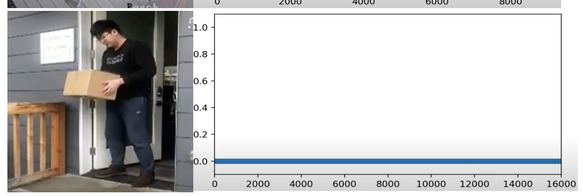


Result and Evaluation

Result:

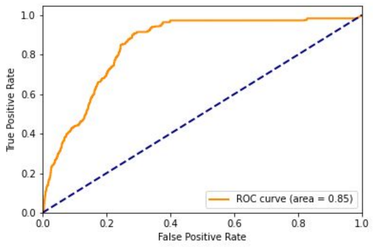
- The x-axis in the pictures represents the frame number and the y-axis represents the anomaly score. Pictures below show that our model can generate high anomaly score for package theft scenes and low anomaly score for normal scenes.





Evaluation:

- The evaluation metrics used in this project are ROC curve and AUC:
- ROC (Receiver Operating Characteristics Curve): The ROC curve shows the performance of a classification model at all classification thresholds.
- AUC (Area under the ROC Curve): AUC tells how much the model is capable of distinguishing between different classes.
- The following figure shows the performance of our model:



AUC (Overall)	0.85

Future Work and References

Future Work:

1. Add object detection to the system to improve the performance
2. Train the model with more data to improve the performance.
3. Build a user-friendly interface

[1] Waqas Sultani, Chen Chen, Mubarak Shah; Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2018, pp. 6479-6488
[2] Z. Cao, G. Hidalgo, T. Simon, S. -E. Wei and Y. Sheikh, "OpenPose: Realtime Multi-Person 2D Pose Estimation Using Part Affinity Fields," in IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 43, no. 1, pp. 172-186, 1 Jan. 2021, doi: 10.1109/TPAMI.2019.2929257.
[3] Prasun Roy, 2019, [OpenPose PyTorch], https://github.com/prasunroy/openpose-pytorch

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