Team Copy-Waste - Vlog 3 Script

Team Member (Re)introductions

- Nolan - Machine Learning Lead
- Will - Back-End Services Lead
- Rishabh - Front-End Services Lead

Vision:

Our project has two objectives; reduce risks to the public, waste management employees and facilities and reduce the cost to municipalities and waste management companies caused by rare and severe contaminants in recycling waste collection.

Mission

We strive to achieve this mission by automating the detection of severe and rare contaminants in the recycling stream

Business Need

Our business need, to reiterate, is to reduce risk and cost to municipalities and waste management employees. As recycling rates increase, contamination and risk becomes a growing concern.

Fires are a major concern at waste facilities: Here in Regina there have been two serious incidents in the past year.

A report by Ryan Fogelman at Fire Rover estimates these incidents cost municipalities and waste management companies 1.2 Billion dollars each year.

In addition to the immediate threats posed by fires, there are long term health impacts resulting from smoke and hazardous fumes. If recycling material is ignited in transit, these risks are presented to the surrounding communities and general public.

Opportunity and Innovation

Traditional Machine learning requires thousands or millions of annotated images to train detection models. There are some public datasets, such as TrashNet that contain images of common recycling contamination and waste.

We are attempting to detect rare items which are not found in these datasets. Some of these objects include hazardous material such as a propane tank, needles, and batteries. These contaminants do not occur commonly, however, they are critical to detect because they pose an immediate risk. To our knowledge, there are no known image datasets for these objects in waste, publicly or privately. Our goal is to create a process using the copy paste algorithm to

take a small sample set of annotated objects and return a large dataset of annotated images. Not only will this project allow us to train models for objects which were previously undetectable, this process will also drastically reduce the amount of time and resources required to create image masks for new contaminants.

Simple Copy-Paste

- Simple Copy-Paste Algorithm
    - These are some examples of how copy-paste is implemented
- Explanation:
    - In the first image we can see how images of soccer players are merged together with images of animals
    - Another example shows how a new image can be created using samples taken from two other images.

This diagram shows How we use the Copy-Paste Algorithm in our Dataset Pipeline

- Waste Management worker requests an object for detection
- Example images of objects are collected
- Annotate and categorize those images of the object
- Copy-Paste Algorithm (How)
    - Combine existing images of waste (~4,000 - 100,000) with new annotated objects (5-10).
    - Generate a new dataset which contains the requested object (~4,000 - 100,000)
    - This allows us to generate large datasets using 10 real images of the object
- Output new dataset of requested image
- Use 80% of the dataset is used to train the detection model (Mask-R-CNN)
- Test detection model against the control dataset (20% of the original dataset)
- Evaluate results and retrain model until the performance is acceptable for deployment

Partnership

We have established a partnership with Prairie Robotics to use their platform to build our product. As our project sponsor, Prairie Robotics will be providing mentorship, knowledge and resources to help us achieve our goal.

Customers

Our primary customers are waste management companies and municipalities in western Canada which require detection of rare and severe contamination to reduce risk of dangers and address high costs.

Current:

- Mitacs Application Submitted
- Phase 1 Nearing completion
- Bit Tip Detector model has been trained
- GreenScreen Dashboard architecture developed

Individual Contributions:

Nolan:

- Research into Yolo and variants, collecting false positive image datasets
- Annotationed false positive images using SuperAnnotate
- completed Yolo training tutorials
- created a script to separate training and test data
- as well as a script to convert annotation results to YOLO format
- Train bin detector in yolov5
- Test bin detector using training dataset

Rishabh:

- Green Screen
    - Implementing the Front-end Architecture in React within Prairie Robotics mono-repository
    - Integrating RBAC sign-in, interactive maps, and coloured panels and text to indicate the performance of regions when recycling is collected
    - Green Screen status documentation and scrums for continuous development
- Integrating data using the Streamsight API

Will:

- Collecting True Negative image datasets
- Annotated images using SuperAnnotate
- YOLO research/tutorials
- Separated and categorized images for testing and training using python scripts
- Created, ran, and generated results for initial YOLO detection model

Status description

GREEN

Project issues

The bin detector is awaiting deployment by PR onto a waste truck for real-world testing.

There were several issues regarding fetching data using the Streamsight API, however, these were addressed by working closely with members of Prairie Robotics.

Project changes

No changes at this point in time.

Knowledge Management Overview

In order to remain coordinated and on schedule we have been conducting weekly sprint planning and retrospectives. During these meetings we discuss our Trello board which contains actionable items under different columns (backlog, doing, done, etc). We take meeting minute notes and upload the documents to github after each meeting.

Green Screen Overview

Green Screen is now a working front-end with a sign-in flow and an interactive map which displays the different collection regions within Regina. Once a region is clicked, various information including the number of offenders, contaminants detected, and contamination rate are displayed. This information is accompanied with green, orange, and red coloured panels and text to indicate how each category is performing.

Bin Tip Overview

Here are some images generated from running our bin tip detector against the dataset that we collected. You can see it detecting multiple object classes and beside the object title there is a number value representing the model's confidence.

In this slide we can see a number of metrics for Average Precision (Ap) and Mean Average Precision (mAP). This average represents how close the predicted bounding box is compared to the ground truth bounding box. Our model was trained with 30 epochs; the graphs show how our model improved with each iteration. As the model reached 30 epochs, the Average precision was above 95% and our losses were below 2%.

This means that our model is correctly identifying and classifying more than 95% of our validation images correctly.

The confusion matrix demonstrates the percentage of times our model properly detected an object to be the same class which we labelled it as. You can see that our model detects each class with 99 or 100 percent accuracy. However, our model occasionally mistakes background objects as one of the object classes. This is more so seen with classes which we were not able to collect as many images for.

Next up

Team

- Meetings planned with our Advisors and with Prairie Robotics
- Deploying our bin detector to a truck’s edge computer
- Begin phase 2 (copy paste pipeline)

Will

- Deploying bin detector to truck

- Benchmark the detector on edge computer and compare with previous model
- Onto the copy paste pipeline

Nolan

- Test bin detector by deploying model to PR test truck
- Measure bin detector real-time performance on edge computer
- Measure bin detector performance against existing model
- Move onto Phase 2, begin implementation of the Simple Copy-Paste algorithm.

Rishabh

- Completing and resolving issues regarding integration with the Streamsight API
- Begin planning and documenting tasks regarding an Email Notification System connected to the dashboard to inform users when hazardous waste is detected and give updates on the general health of recycling
- Planning for the implementation of the copy-paste pipeline

Retrospective

What went well?

- We believe we did a great job of maintaining strong communication and regularly scheduling dedicated time for working towards our project goals throughout the semester.

What could be improved?

- We would like to expand our Trello board by implementing a more fleshed out standard of building epics with more information such as user stories and tasks to improve our project management

What will the team commit to continue or change in ENSE 477?

- Continue consistent communication & developments
- In the next semester we would like to dedicate even more time towards project work

Team Reflection

- **Does the team feel "on track"? (reiterate the above colour status)**
    - We believe we are still on track, time management has been a challenge. We have mostly completed our first phase and should be able to fully complete it shortly.
- **What progress does the team particularly feel good (great) about?**
    - The entire bin detector process went very smoothly. From collecting images, annotating images, creating the initial model, and tweaking the model until it reached a certain level of performance, there were minimal bumps in the road.

    - We are very excited to have completed and submitted our Mitacs proposal
- **What barriers (if any) does the team feel is a current impediment to success?**
    - The bin detector model still needs to be deployed to an actual truck to test true performance
- **What help (if any) does the team require to move positively forward?**
    - We will need to meet with PR for guidance on beginning planning and development for the copy paste pipeline
- **What questions or concerns does the team have (if any)?**
    - No concerns at this time