Technical documentation

Note: this project in an updated version is also available on https://github.com/standa42/master-thesis-implementation, at the moment private only for collaborators.

Minimal requirements

- Python > 3.7
- GPU with CUDA support (was not tested on CPU but the expectation is that both training and inference will be too slow for reasonable usage)

Installation of the environment

The main parts of the project run in two Anaconda(3) environments. The installation of Anaconda is required (https://www.anaconda.com/). To install environments and install the project as the package to enable in-package references, start by opening the anaconda console and changing the directory to the root of the project:

cd "master-thesis-implementation"

To install tfg7 environment, execute:

conda env create -f environment-tfg7.yaml

To install try1 environment, execute:

conda env create -f environment-try1.yaml

In order to install the project as a package, execute:

pip install -e "."

Project structure

- **bin/** - contains main scripts for execution and kivy applicaiton
- **src/** - contains 'library' code that is referenced from the bin folder
- **data/** - contains all the data in the projects
- **config/** - configuration files
- **docs/** - documentation
- **model/** - stores trained neural networks and machine learning models

- **yolo_repository/** - copy of standalone repository by authors of yolov5, that we were using for training yolo neural networks (https://github.com/ultralytics/yolov5)
- **environment-*.yaml** - conda environment definitions
- **requirements_yolo.txt** - copy of local environment that was used for yolo training
- **setup.py** - setup of the project package

Conda envs

The main reason for two conda environments were issues with incompatibilities of a combination of tensorflow, pytorch, scikit and numpy. The tfg7 environment is specialized in working with yolo in pytorch a should be used as default. The try1 environment is specialized in working with classification cnn's in tensorflow and is needed only for those scripts (classification.py, classification_server.py).

- tfg7 - original environment - torch (yolov5)
- try1 - rims classification - tf, flask

Main UI application

The main UI application is located in .\bin\trackingapp\TrackingApp.py. The UI is based on the multiplatform UI framework kivy. The application consists of 4 screens (.py file for each) and the layout they are using is described in .kv file in kivy language.
For more on the application usage, see User documentation.

Models

There are currently few pre-trained models, located in ./model/folder

- tracking_v2_yolo.pt - yolov5s model for detection of wheel and car
- size_estimation_256_yolo.pt - yolov5s model for detection of rim and bolts
- rims_classification_checkpoints/…dataset31/ - classification model for dataset31
- rims_classification_checkpoints/…dataset21/ - classification model for dataset21

- tracking_yolo.pt - old version of tracking_v2_yolo.pt
- whee_bolts_detection_yolo.pt - old version of size_estimation_256_yolo.pt with support only for bolts

Data folders

The folders in ./data/ contain various types of the data:

- **Raw**

    - Contains raw data in zip files. Single zip file is expected to contain all the data from one day
    - Expected format is: ./data/raw/yyyy_mm_dd/yyyy_mm_dd.zip
    - For example: ./data/raw/2019_05_13/2019_05_13.zip
- **Video**
    - Contains videos. One folder is expected to contain all videos for one day
    - Expected format is: ./data/video/yyyy_mm_dd/yyyy_mm_dd_hh_mm_ss_camera.mp4
    - For example: ./data/video/2019_05_13/2019_05_13_10_48_35_A.mp4
- **Frames**
    - Contains frames of individual videos
    - There are 600 frames in a single 10 minute interval on a single camera, because the videos are 10 minutes long with 1 frame per second
    - Folder structure is day/time/camera/frame[frame_number in format XXX].jpg
    - For example: ./data/frames/2019_05_13/10_48_35/A/frame021.jpg
- **Crops**
    - Crops of objects extracted from frames, mainly wheels of size (770, 770)
    - Structure is flat - in folder ./data/crops/ there are images saved as 2019_05_13_10_48_35_A_frame000_bb0_Wheel.png
    - The format is day_time_camera_frameXXX_bb[number of extracted crop from single image - for cases where there are more objects in one image]_[class].png
- **Downscaled Crops**
    - Crops as above, but all scaled to (256, 256)
    - Folder is ./data/scaled_down_frames/ and format of files is the same as in Crops
- **Dataset31**
    - Contains dataset31. Because the subset of dataset31 is dataset21, it can be extracted from it. For a practical example see script classification.py
- **unique_rims_collage**
    - Contains representative images for individual classes of rims
- **tracking_dataset_v2**
    - Contains dataset for object detection of cars and wheels
- **size_estimation_dataset**
    - Contains dataset for object detection of rims and bolts

The pipeline description

Chapter two - car and wheel detection

The expected data input are folders of individual videos, that contain all the videos for that day (see folder documentation Raw and Video)

To unzip zips, we can put them in ./data/raw and run extract_zips.py scripts.

The videos are then parsed to individual frames by parse_videos_to_frames.py

From those frames, we have created a dataset for car and wheel tracking by random selection described in the thesis. The script for that is generate_random_frames_sample.py.

The dataset is labelled in CVAT tool and converted to YOLO format.

The dataset is then trained via Yolo repository, see section YOLO repository.

Chapter three - classification of wheels

First, all crops of wheels are extracted into Crops folder by script extract_tracking_crops.py. Then they need to be scaled down to (256, 256) by scale_down_crops.py script.

From scaled down crops, wheel class samples were picked by hand and later sampled into the dataset by dataset21_31_selection.py as it is described in the third Chapter of the thesis.

To train classification models, the classification.py is used.

Chapter four - rim and bolts detection

To generate the dataset generate_wheel_detection_dataset.py script is used.

The dataset is labelled in CVAT tool and converted to YOLO format.

The dataset is then trained via YOLO repository, see section YOLO repository.

Application

The description of application can be found in User documentation.

YOLO repository

The YOLO repository si stored in ./yolo_repository/. It is original repository from the authors of the yolov5 model. See https://github.com/ultralytics/yolov5. The github repo contains documentation on training on custom data. The installation is also describe on this github

and is done via requirements.txt in the repository. For potential issues with installtion we have also included pip environment setting on our machine (requirements_yolo.txt in root folder of the project).

The main parts we were using are data*.yaml files where we can specify the paths to training and validation data, as well as classes in the dataset.

The hyperparameters and augmentations the model is using are described in ./data/hyps/ folder.

The training is executed by command like:
python train.py --img 640 --batch 6 --epochs 50 --data data.yaml --weights yolov5n.pt --workers 1
in the root directory of this repository.

The training runs are then stored into ./runs/train/. The repository already contains runs of the experiments performed in the thesis.

List of all the video data that were used

Because all the video data used for the thesis have a memory size of tens of gbs, we have included only a small portion of the data in the attachment. The rest of the data can be in practice requested from the supervisor or the author of the thesis.
List of all the videos we have been using is:

2019_05_13_10_48_35_A.mp4
2019_05_13_10_48_35_B.mp4
2019_05_13_10_58_53_A.mp4
2019_05_13_10_58_53_B.mp4
2019_05_13_11_09_12_A.mp4
2019_05_13_11_09_12_B.mp4
2019_05_13_11_19_31_A.mp4
2019_05_13_11_19_31_B.mp4
2019_05_13_11_29_49_A.mp4
2019_05_13_11_29_49_B.mp4
2019_05_13_11_40_10_A.mp4
2019_05_13_11_40_10_B.mp4
2019_05_13_11_50_31_A.mp4
2019_05_13_11_50_31_B.mp4
2019_05_13_12_00_47_A.mp4
2019_05_13_12_00_47_B.mp4
2019_05_13_12_11_08_A.mp4
2019_05_13_12_11_08_B.mp4
2019_05_13_12_21_21_A.mp4
2019_05_13_12_21_21_B.mp4
2019_05_13_12_31_40_A.mp4
2019_05_13_12_31_40_B.mp4
2019_05_13_12_42_01_A.mp4
2019_05_13_12_42_01_B.mp4
2019_05_13_12_52_21_A.mp4
2019_05_13_12_52_21_B.mp4
2019_05_13_13_02_40_A.mp4
2019_05_13_13_02_40_B.mp4
2019_05_13_13_13_00_A.mp4
2019_05_13_13_13_00_B.mp4
2019_05_13_13_23_18_A.mp4
2019_05_13_13_23_18_B.mp4
2019_05_13_13_33_40_A.mp4
2019_05_13_13_33_40_B.mp4
2019_05_13_13_44_01_A.mp4
2019_05_13_13_44_01_B.mp4
2019_05_13_13_54_20_A.mp4
2019_05_13_13_54_20_B.mp4
2019_05_13_14_04_41_A.mp4
2019_05_13_14_04_41_B.mp4
2019_05_13_14_15_01_A.mp4
2019_05_13_14_15_01_B.mp4
2019_05_13_14_25_23_A.mp4
2019_05_13_14_25_23_B.mp4
2019_05_13_14_35_43_A.mp4
2019_05_13_14_35_43_B.mp4
2019_05_13_14_46_02_A.mp4
2019_05_13_14_46_02_B.mp4
2019_05_13_14_56_23_A.mp4
2019_05_13_14_56_23_B.mp4
2019_05_13_15_06_43_A.mp4
2019_05_13_15_06_43_B.mp4
2019_05_13_15_16_58_A.mp4
2019_05_13_15_16_58_B.mp4
2019_05_13_15_27_16_A.mp4
2019_05_13_15_27_16_B.mp4
2019_05_13_15_37_37_A.mp4
2019_05_13_15_37_37_B.mp4
2019_05_13_15_47_58_A.mp4
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2019_05_13_16_39_41_A.mp4
2019_05_13_16_39_41_B.mp4
2019_05_13_16_50_02_A.mp4
2019_05_13_16_50_02_B.mp4
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2019_05_13_17_00_16_B.mp4
2019_05_13_17_10_35_A.mp4
2019_05_13_17_10_35_B.mp4
2019_05_13_17_20_56_A.mp4
2019_05_13_17_20_56_B.mp4
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2019_05_14_16_41_09_B.mp4
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2019_05_14_17_12_11_B.mp4
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2019_05_14_17_22_31_B.mp4
2019_05_14_17_32_49_A.mp4
2019_05_14_17_32_49_B.mp4
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2019_05_14_17_43_10_B.mp4
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2019_05_14_17_53_30_B.mp4
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2019_05_14_18_14_10_B.mp4
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2019_05_14_19_05_13_B.mp4
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2019_05_14_19_15_32_B.mp4
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2019_05_14_19_36_13_B.mp4
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2019_05_14_19_46_32_B.mp4
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2019_05_14_20_07_12_B.mp4

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2019_05_14_20_17_32_B.mp4
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2019_05_14_22_00_37_B.mp4
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