



aws INNOVATE

AI/ML EDITION

24 February 2022

Build an AWS Deep Lego Train

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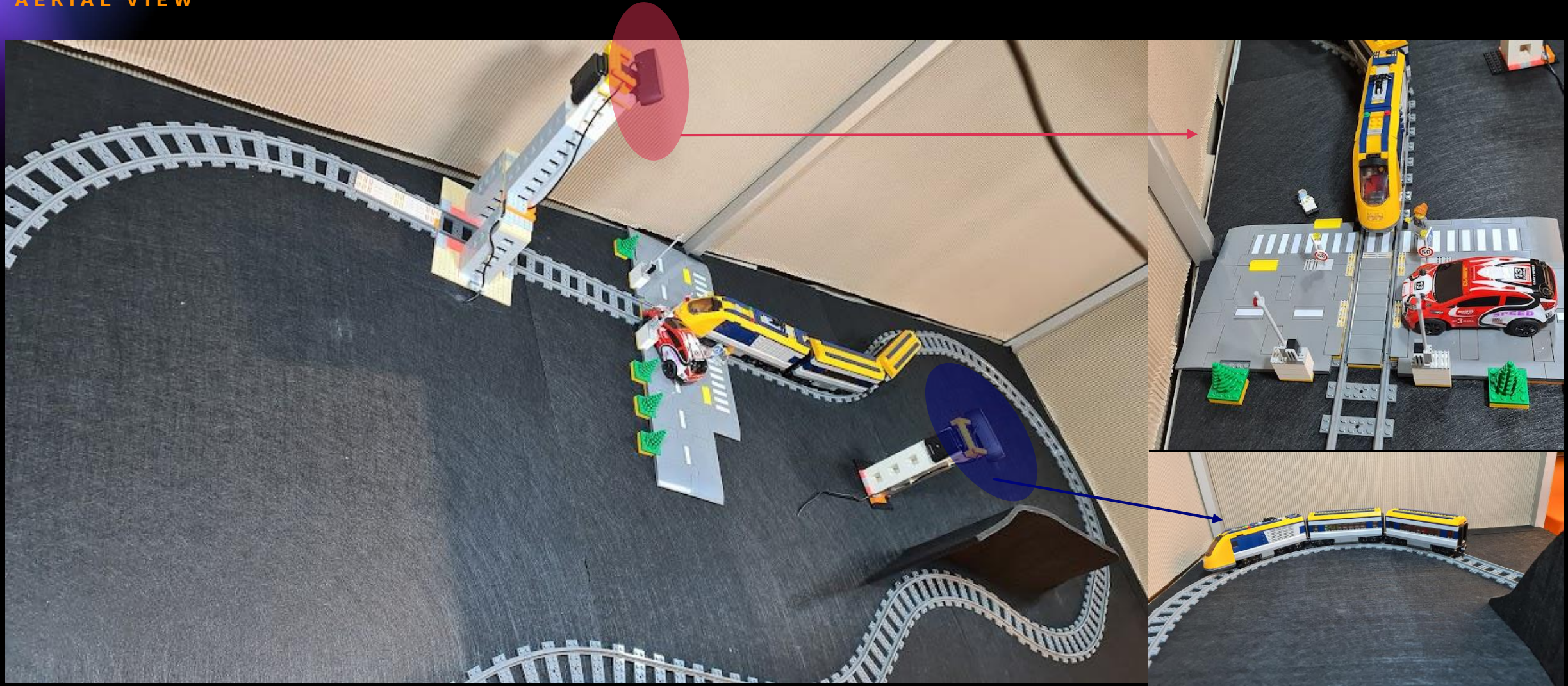


Agenda

1. Use case
2. Solution architecture
3. Creating training data
4. Data labelling
5. Amazon SageMaker Studio & model training
6. Running inference on a physical device

Use Case

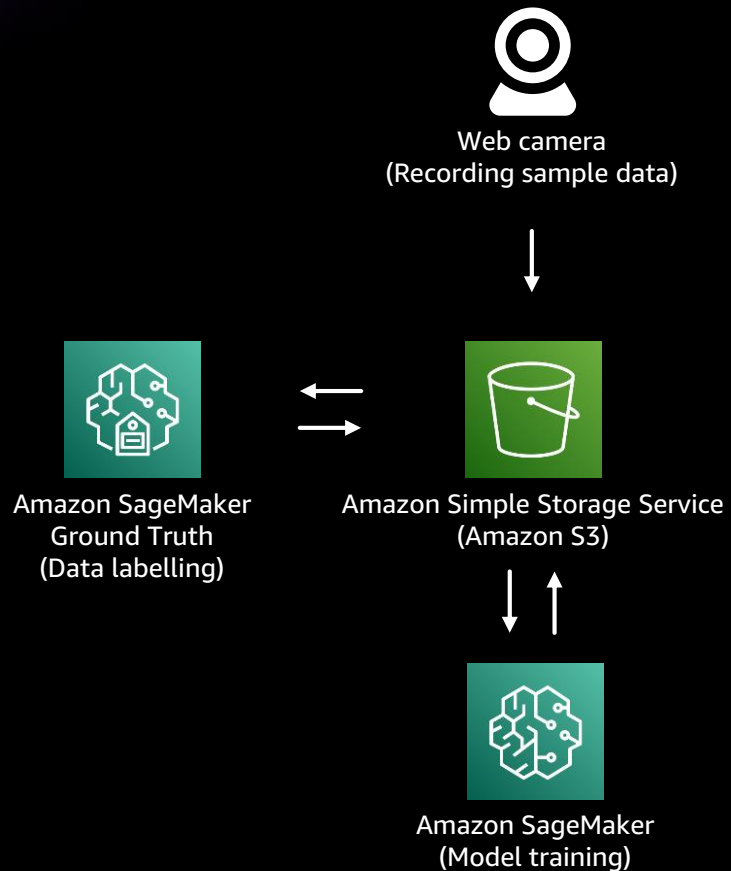
AERIAL VIEW



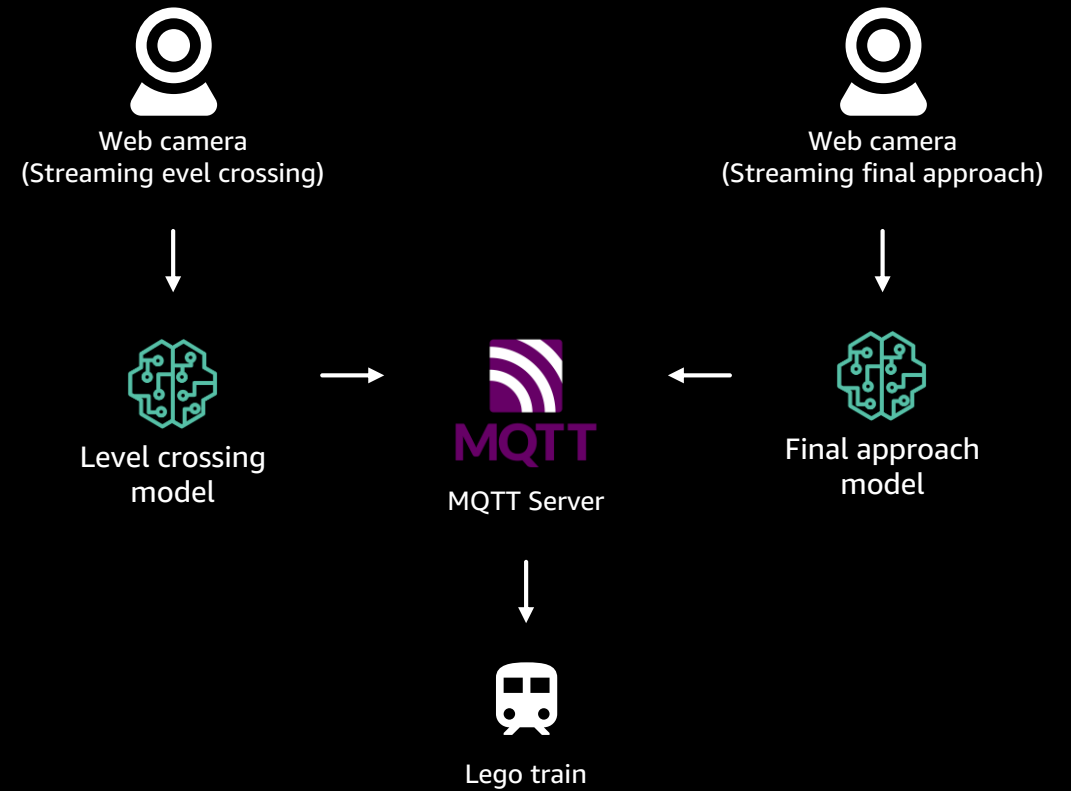
Solution Architecture

SOLUTION WORKFLOW

Training phase

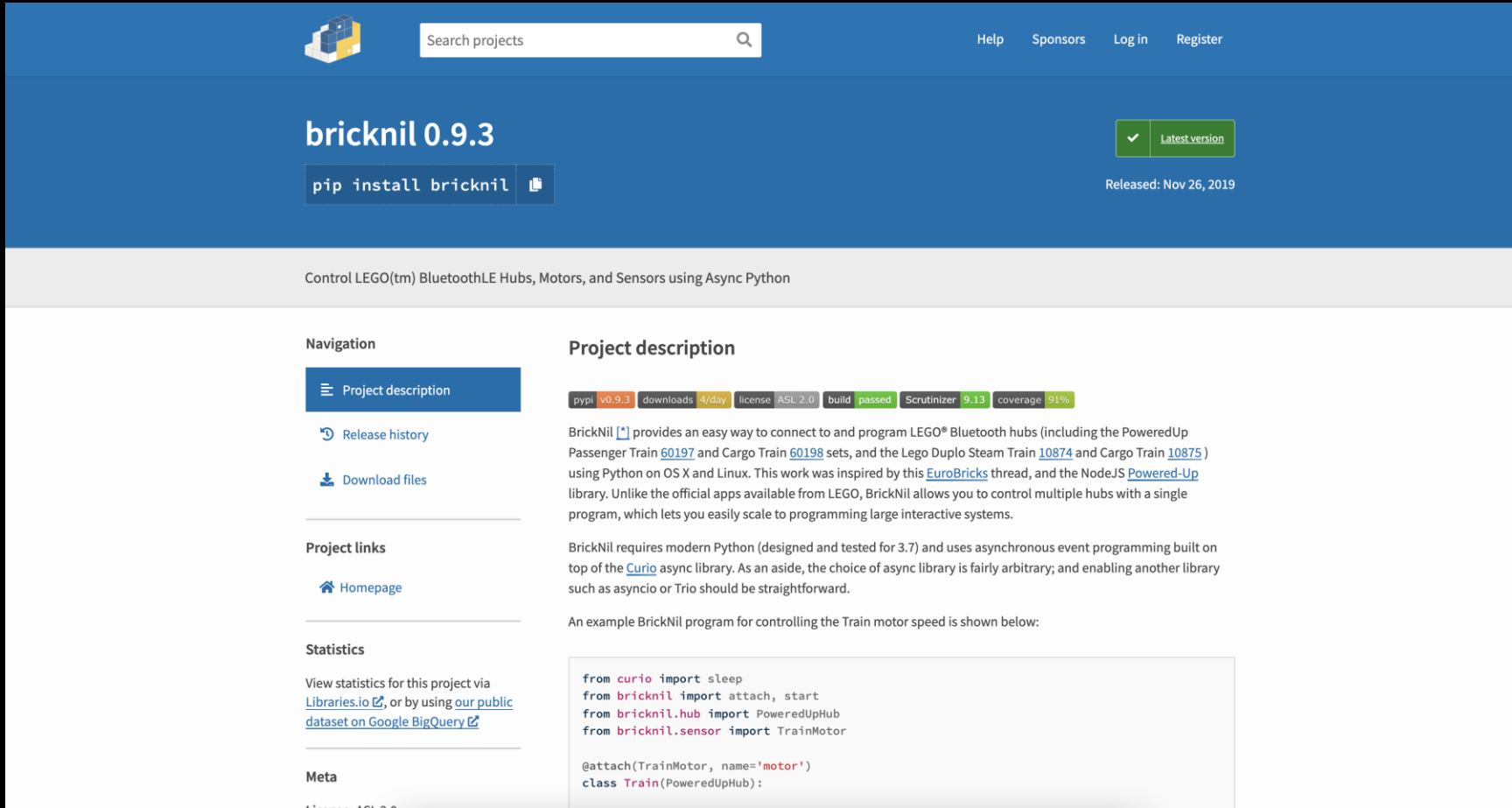


Execution phase



Solution Architecture

CONTROLLING LEGO TRAIN – "BRICKNIL" ON PYPI & GITHUB



The screenshot shows the PyPI project page for **bricknil 0.9.3**. The page has a blue header with the project logo, a search bar, and links for Help, Sponsors, Log in, and Register. Below the header, the project name **bricknil 0.9.3** is displayed, along with a green badge indicating it is the "Latest version" and a release date of "Released: Nov 26, 2019". A button shows the command `pip install bricknil`. The main content area is divided into two columns. The left column contains a "Navigation" sidebar with links to "Project description", "Release history", and "Download files", followed by "Project links" (Homepage) and "Statistics". The right column, titled "Project description", contains a summary of the project, a table of badges (pypi, version, downloads, license, build, Scrutinizer, coverage), a detailed description of the project's purpose and inspiration, and a code example for controlling a LEGO train motor speed.

Control LEGO(tm) BluetoothLE Hubs, Motors, and Sensors using Async Python

Navigation

- Project description
- Release history
- Download files

Project links

- Homepage

Statistics

View statistics for this project via [Libraries.io](#), or by using [our public dataset on Google BigQuery](#)

Meta

License: [ASL 2.0](#)

Project description

BrickNil provides an easy way to connect to and program LEGO® Bluetooth hubs (including the PoweredUp Passenger Train [60197](#) and Cargo Train [60198](#) sets, and the Lego Duplo Steam Train [10874](#) and Cargo Train [10875](#)) using Python on OS X and Linux. This work was inspired by this [EuroBricks](#) thread, and the NodeJS [Powered-Up](#) library. Unlike the official apps available from LEGO, BrickNil allows you to control multiple hubs with a single program, which lets you easily scale to programming large interactive systems.

BrickNil requires modern Python (designed and tested for 3.7) and uses asynchronous event programming built on top of the [Curio](#) async library. As an aside, the choice of async library is fairly arbitrary; and enabling another library such as `asyncio` or `Trio` should be straightforward.

An example BrickNil program for controlling the Train motor speed is shown below:

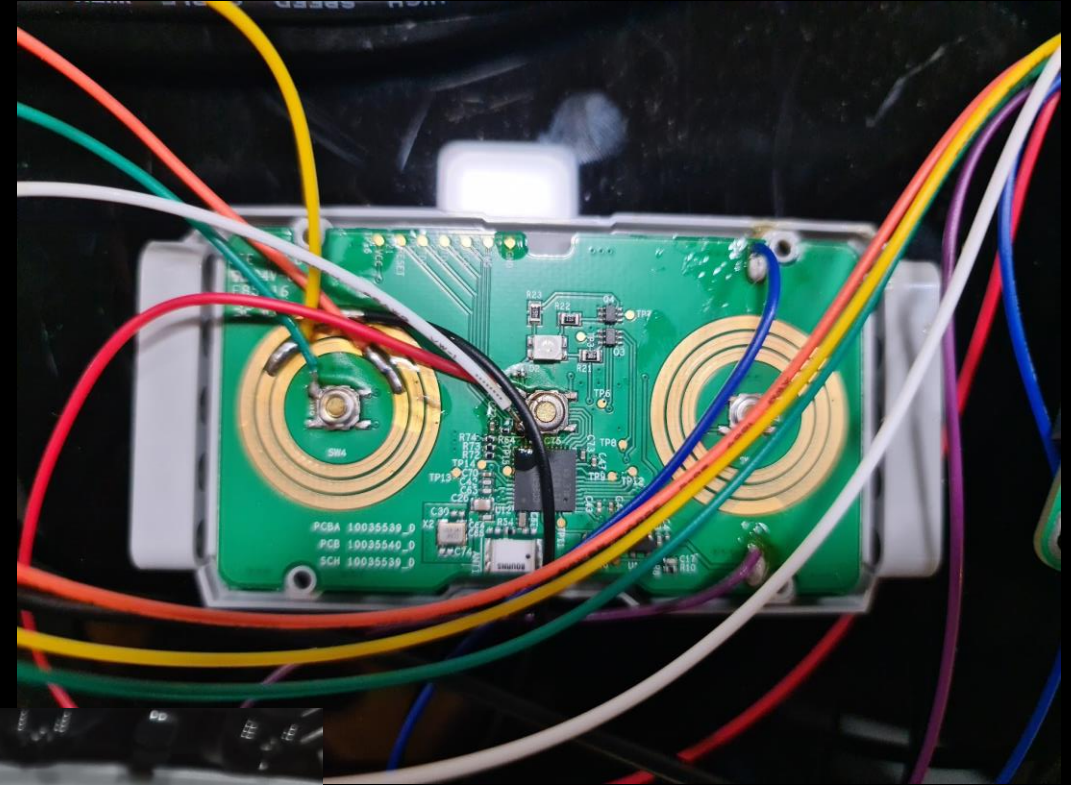
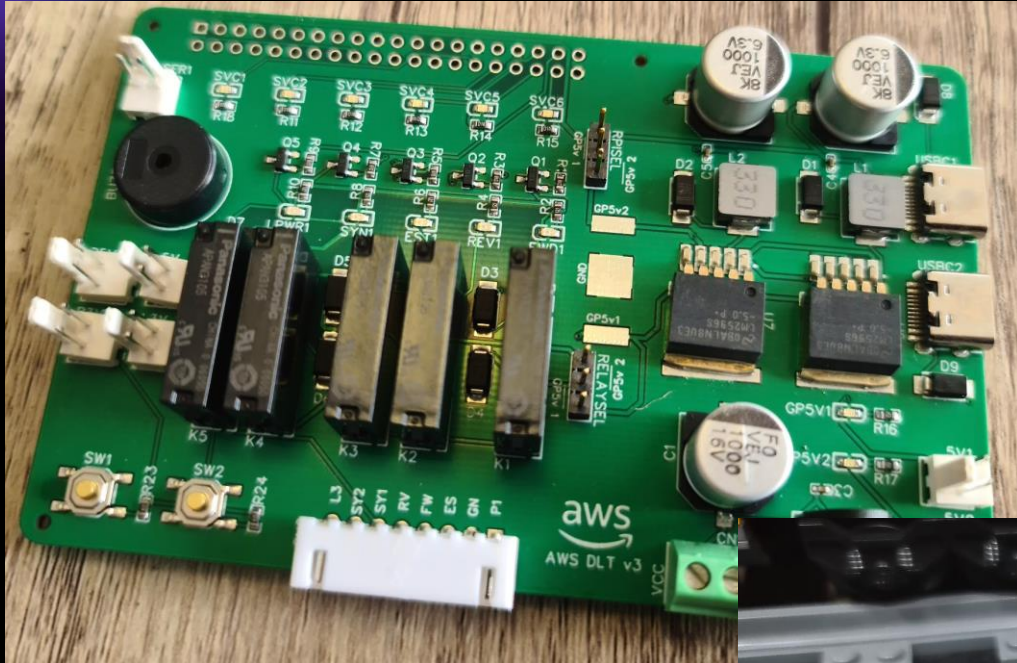
```
from curio import sleep
from bricknil import attach, start
from bricknil.hub import PoweredUpHub
from bricknil.sensor import TrainMotor

@attach(TrainMotor, name='motor')
class Train(PoweredUpHub):
```

[Reference link](#)

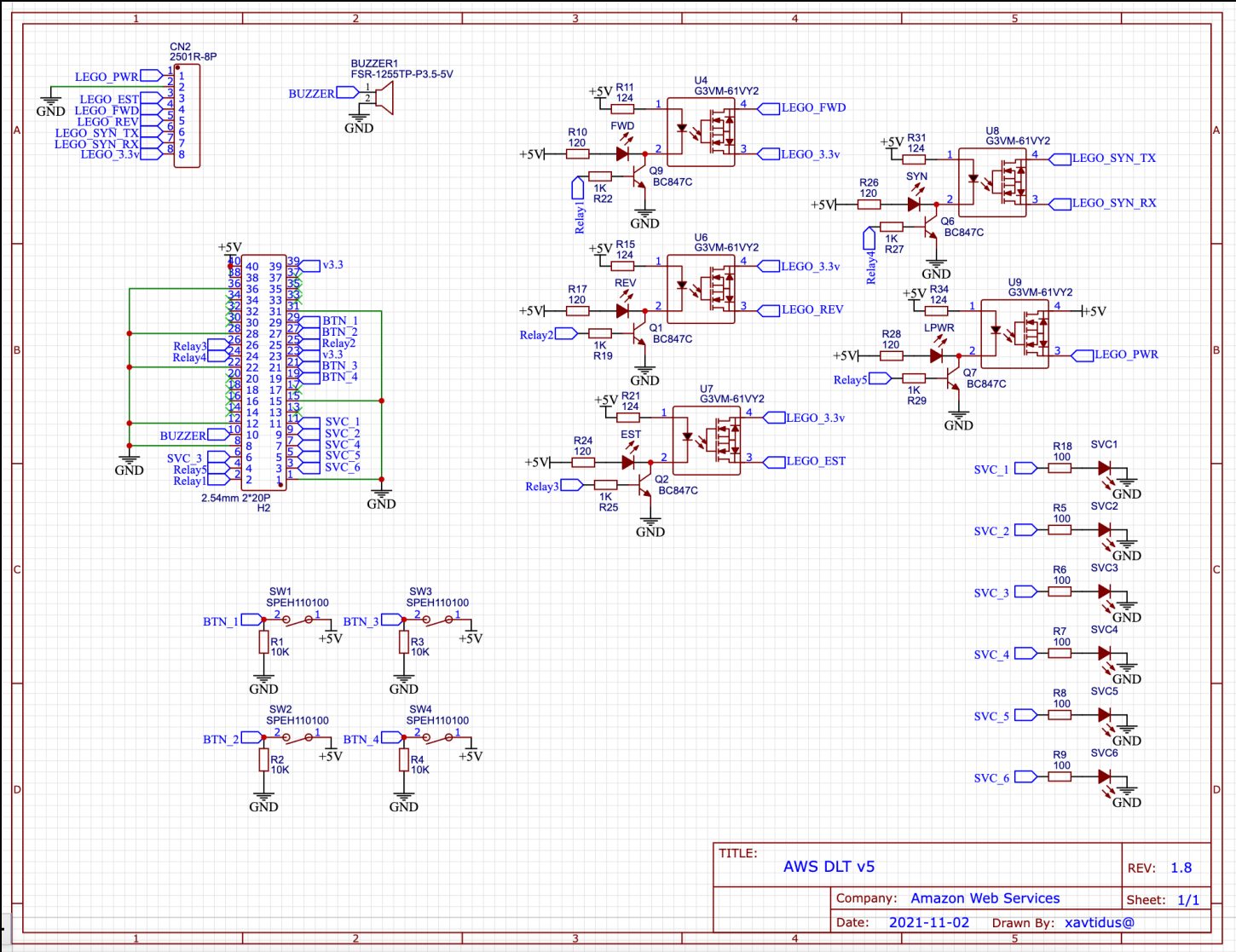
Solution Architecture

PCB DESIGNS



Solution Architecture

PCB SCHEMATIC



Training Data Creation

CAPTURE ENVIRONMENT FOR TRAINING



Web Camera
(Recording Sample Data)



Record Video



Edit Video to remove
unnatural conditions



Extract frames for
processing



Upload to
Amazon S3

**Video: manual-training-
manipulation.m4v**

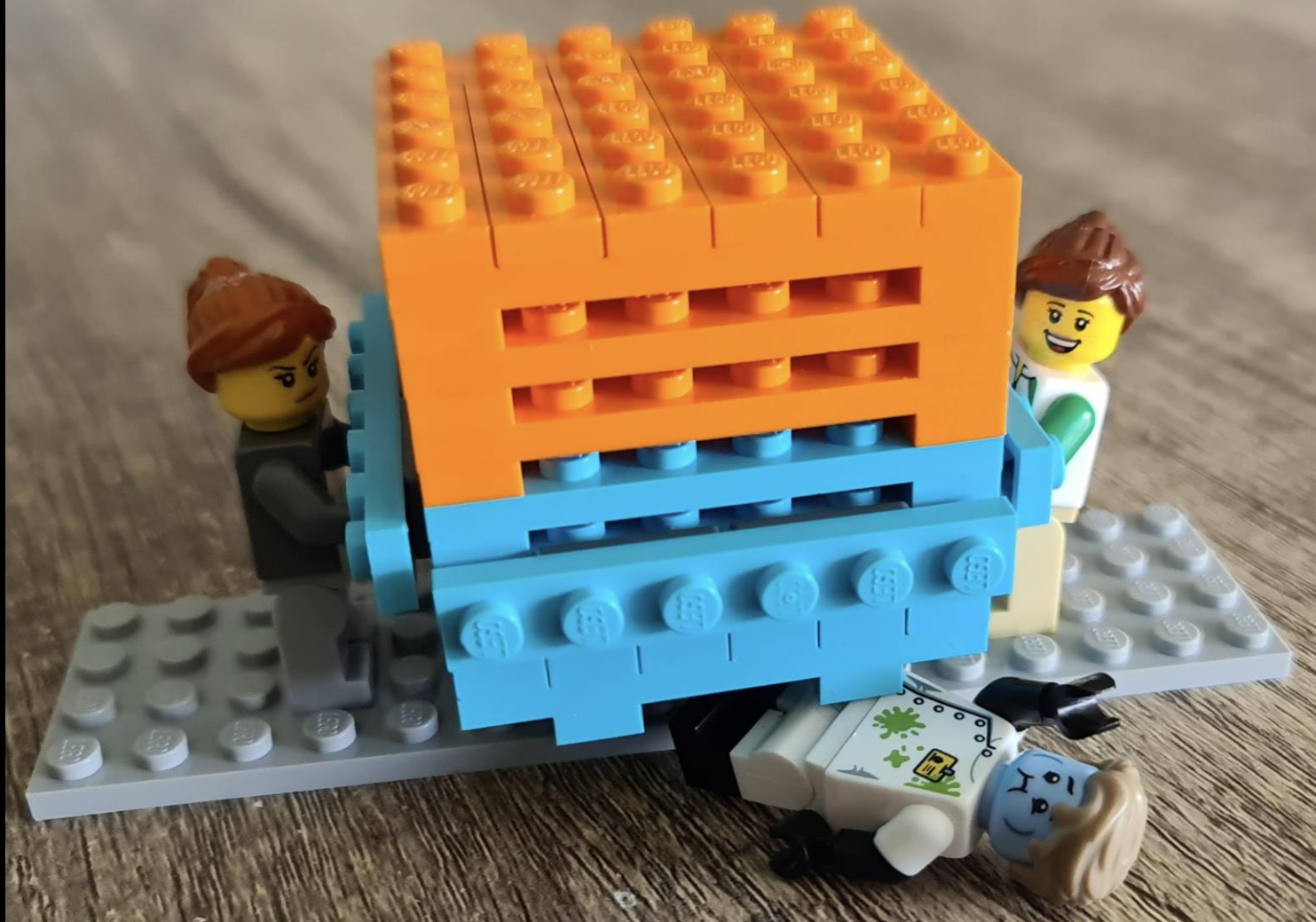
Video: video-edit-removing-hands.mov

Video: **extract-frames.trec**

Video: upload-frames-to-s3.trec

Amazon SageMaker

REMOVES A LOT OF HEAVY LIFTING FROM ML WORK



Joey vs a Wallaby



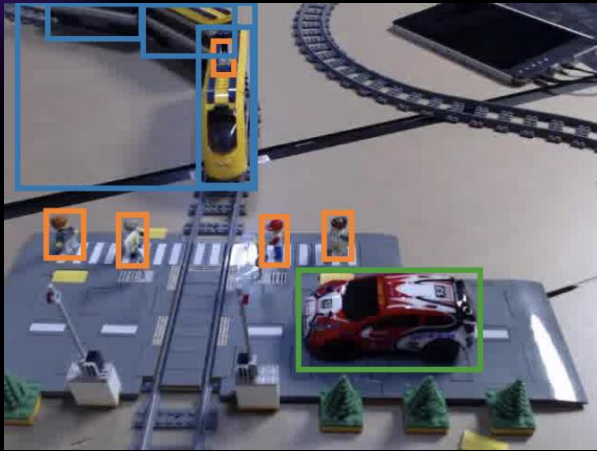
Photo credit: [link](#)



Photo credit: [link](#)

Amazon Mechanical Turk Team

A VIRTUAL AND DISTRIBUTED CROWDSOURCING MARKETPLACE FOR OUTSOURCED ACTIVITIES



Labels (10)					
<input type="text" value="Search by label name"/>					
Label name	Source	Confidence	Task type	Label creation time	
car	Human annotated	0.90	Bounding box	Jan 11, 2022, 10:22 AM UTC	
person	Human annotated	0.79	Bounding box	Jan 11, 2022, 10:22 AM UTC	
person	Human annotated	0.78	Bounding box	Jan 11, 2022, 10:22 AM UTC	
person	Human annotated	0.74	Bounding box	Jan 11, 2022, 10:22 AM UTC	
person	Human annotated	0.77	Bounding box	Jan 11, 2022, 10:22 AM UTC	
person	Human annotated	0.36	Bounding box	Jan 11, 2022, 10:22 AM UTC	
train	Human annotated	0.71	Bounding box	Jan 11, 2022, 10:22 AM UTC	
train	Human annotated	0.57	Bounding box	Jan 11, 2022, 10:22 AM UTC	
train	Human annotated	0.42	Bounding box	Jan 11, 2022, 10:22 AM UTC	
train	Human annotated	0.64	Bounding box	Jan 11, 2022, 10:22 AM UTC	

Video: create-ground-truth- job.trec

Video: ground-truth-results- review.trec

Amazon SageMaker Studio

PROVIDES A SINGLE, WEB-BASED VISUAL INTERFACE WHERE YOU CAN PERFORM ALL ML DEVELOPMENT STEPS

The screenshot displays the Amazon SageMaker Studio web interface. On the left, a Jupyter notebook titled 'random_cut_forest.py' is open, showing Python code for computing anomaly scores. The code includes imports, data loading, model inference, and plotting. The notebook text is as follows:

```
Computing Anomaly Scores

Now, let's compute and plot the anomaly scores from the entire taxi dataset.

[ ]: results = rcf_inference.predict(taxi_data_numpy)
     scores = [datum['score'] for datum in results['scores']]

     # add scores to taxi data frame and print first few values
     taxi_data['score'] = pd.Series(scores, index=taxi_data.index)
     taxi_data.head()

[ ]: fig, ax1 = plt.subplots()
     ax2 = ax1.twinx()

     #
     # *Try this out* - change 'start' and 'end' to zoom in on the
     # anomaly found earlier in this notebook
     #
     start, end = 0, len(taxi_data)
     #start, end = 5500, 6500
     taxi_data_subset = taxi_data[start:end]

     ax1.plot(taxi_data_subset['value'], color='C0', alpha=0.8)
     ax2.plot(taxi_data_subset['score'], color='C1')

     ax1.grid(which='major', axis='both')

     ax1.set_ylabel('Taxi Ridership', color='C0')
     ax2.set_ylabel('Anomaly Score', color='C1')

     ax1.tick_params('y', colors='C0')
     ax2.tick_params('y', colors='C1')

     ax1.set_ylim(0, 40000)
     ax2.set_ylim(min(scores), 1.4*max(scores))
     fig.set_figwidth(10)

Note that the anomaly score spikes where our eyeball-norm method suggests there is an
anomalous data point as well as in some places where our eyeballs are not as accurate.

Below we print and plot any data points with scores greater than 3 standard deviations
(approx 99.9th percentile) from the mean score.

[ ]: score_mean = taxi_data['score'].mean()
     score_std = taxi_data['score'].std()
     score_cutoff = score_mean + 3*score_std

     anomalies = taxi_data_subset[taxi_data_subset['score'] > score_cutoff]
     anomalies

The following is a list of known anomalous events which occurred in New York City within this
timeframe:
```

On the right side of the interface, there are two panels. The top panel, 'Trial Component Chart', displays a table of trial components and a corresponding scatter plot. The table has columns for Experiment, Trial, Trial Component, and Type. The scatter plot shows 'test-metric with 1-minute aggregation' over time, with data points colored by trial component. The bottom panel, 'Trial Component List', shows a table of trial components with columns for Status, Experiment, Type, Trial, Trial component, and Monitor. The status for all components is 'Completed'.

Experiment	Trial	Trial Component	Type
Fruits111	Apple111	DEMO-minerva-byo-2019-11-14-04-26-00-aws-training-job	arnaws:sage
Fruits111	Apple111	DEMO-minerva-byo-2019-11-14-07-13-55-aws-training-job	arnaws:sage
Fruits111	Apple111	DEMO-minerva-byo-2019-11-14-17-58-13-aws-training-job	arnaws:sage
Fruits111	Apple111	DEMO-minerva-byo-2019-11-19-18-05-53-aws-training-job	arnaws:sage
Fruits111	Apple111	DEMO-minerva-byo-2019-11-19-22-10-02-aws-training-job	arnaws:sage
Fruits111	Apple111	DEMO-minerva-byo-2019-11-19-22-12-34-aws-training-job	arnaws:sage
Fruits111	Apple111	DEMO-minerva-byo-2019-11-20-17-15-39-aws-training-job	arnaws:sage
Fruits111	Apple111	DEMO-minerva-byo-2019-11-21-05-21-26-aws-training-job	arnaws:sage
Fruits111	Apple111	DEMO-minerva-byo-2019-11-21-18-23-16-aws-training-job	arnaws:sage

Status	Experiment	Type	Trial	Trial component	Monitor
Completed	Fruits111	Training job	Apple111	DEMO-minerva-byo-2...	
Completed	Fruits111	Training job	Apple111	DEMO-minerva-byo-2...	
Completed	Fruits111	Training job	Apple111	DEMO-minerva-byo-2...	
Completed	Fruits111	Training job	Apple111	DEMO-minerva-byo-2...	
Completed	Fruits111	Training job	Apple111	DEMO-minerva-byo-2...	

Video: create-sagemaker-studio.trec

Video: [checkout-oneshot.trec](#)

Video: run-through- oneshot.trec

Video: programming-test-code-1.trec

Video: programming-test-code-2.trec

Video: Professional Demo Recording

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- Accelerate machine learning innovation with the right cloud services & infrastructure e-book
- Choosing the right compute infrastructure for machine learning e-book
- Improving service and reducing costs in contact centers e-book
- Why ML is essential in your fight against online fraud e-book
- ... and more!



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twitch.tv/aws

Now it's your turn to build

LEGO SANDBOXES ARE ACTUALLY A FUN PLACE TO START



Thank you!

Xavier Hutchinson

