Automated Toolbox Inventory Control System [ATICS]

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Background

Sponsor has many buildings, each containing several toolboxes

Employees occasionally forget to return tools after use, leading to:

- Disrupted workflows
- Delayed projects
- Increased operational costs

Auditing toolbox inventory is expensive and time consuming

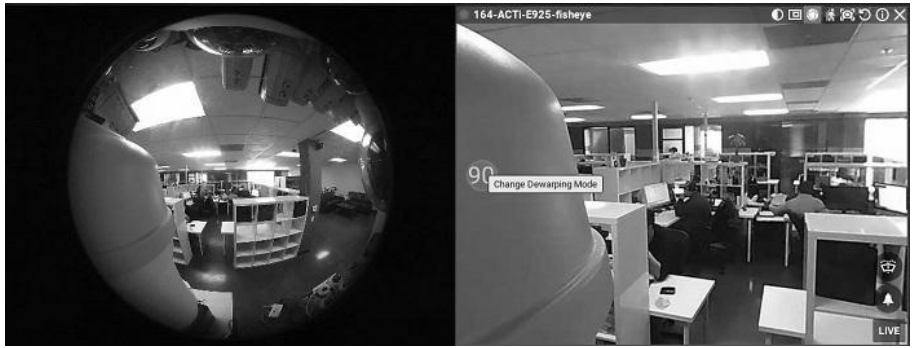
What if auditing process could be automated…

Solution

Develop a computer program implementing the following model:

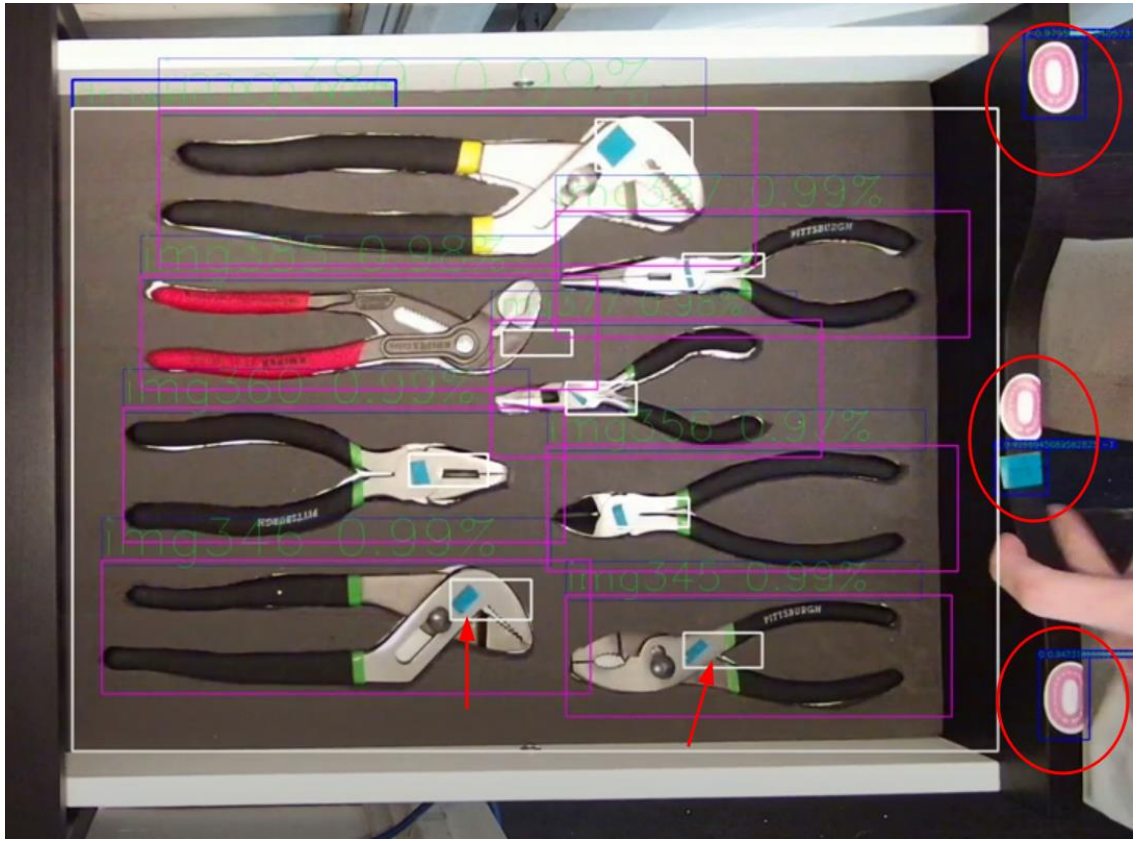
- Toolbox unlocked via RFID badge; triggers inventory audit
- Process video camera footage to identify missing tools
- Assign tools as checked out to employee
- Log tool checkouts in database

Initial Assumptions



- A Camera
  - No warping (fisheye lens)
  - No automatic Zoom
  - Streams over RTSP
- A ToolBox
  - Each Drawer
    - Unique identifying symbols on each drawer
    - Tools arranged in shadow box
  - Each Tool
    - Has Unique symbol
    - Assigned a single location in the drawer

Example Drawer and Tools



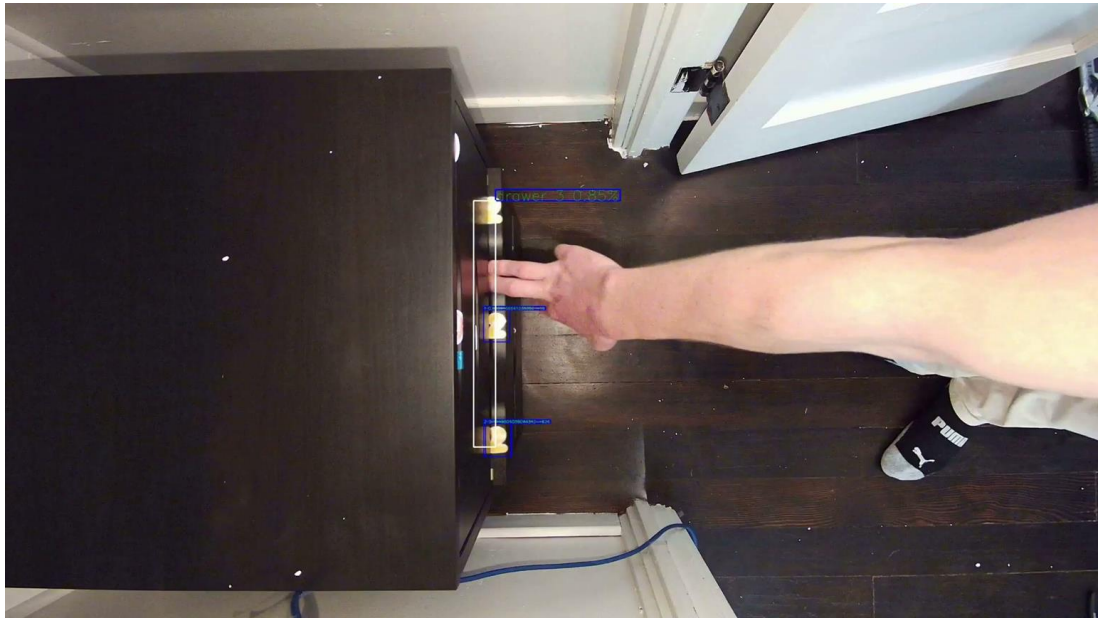
ATICS Components

- Computer Vision:
  - Template Matching
  - Classifier

- Backend Infrastructure :
  - API
  - Database
  - File Server

Computer Vision - Frame processing

- Find drawer using drawer symbols
- Locate tools and determine their status
- Look for extra tools in the drawer



Computer Vision - Template Matching

Template matching - A technique to match areas of an image to a template image.

- Takes 2 inputs:
  - Image in which an item is being searched for
  - Picture of the item to use as a template
- Inputs are used to compare the template picture to the image, moving the template one pixel at a time.
  - After each move, a metric is calculated to show how similar the template is to that particular area of the picture.

Template Matching - Challenges

Technology has difficulties with differences in:

- Lighting
- Rotation
- Size

Computer Vision - Classifier and Deep Neural Network

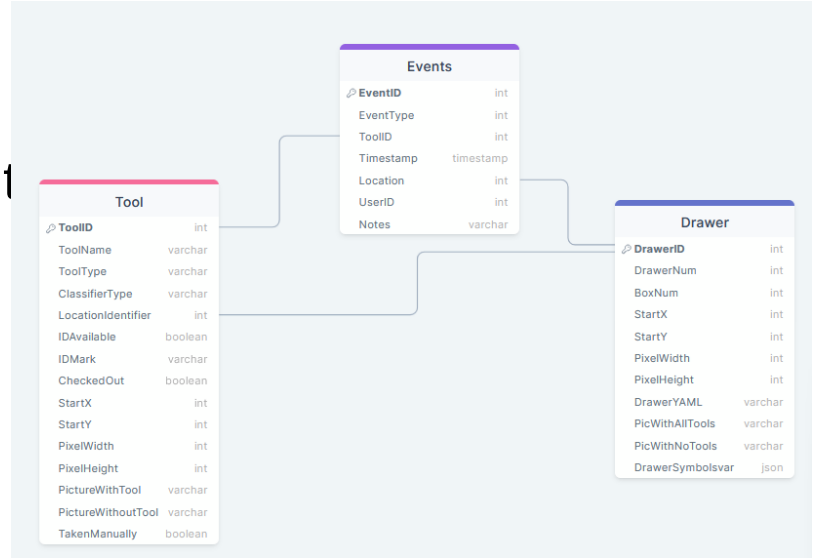
Image Classifier- A trained neural network designed to use PyTorch to use the computer to label images as a predetermined class.

- Training involves exposing the model to a dataset containing annotated images.
- Through iterative optimization, classifier learns to recognize patterns corresponding to the specified tools.
- The learned patterns are then exported as an ONNX configuration file to be used by the template matching portion of the program.

Backend Infrastructure

Database:

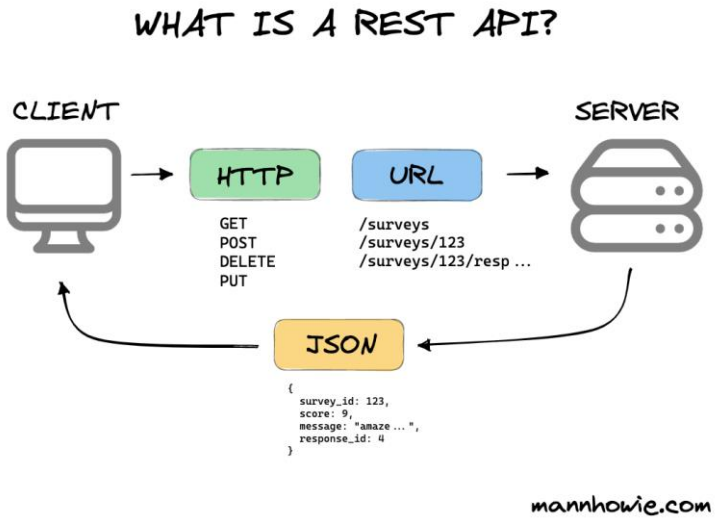
- MySQL server 8.0
- Stores information about tool boxes and drawers
  - Records tool location and checkout status
  - Records check in, check out, and error events
- Schema
- 3 Tables
  - Tools, Events, and Drawers



Backend Infrastructure

API:

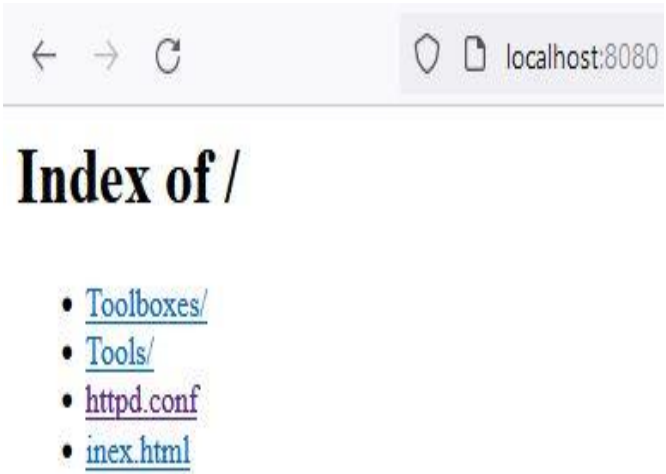
- Written with Flask and Python
- provides communication between the computer vision component and the SQL server.
- Queries are issued by custom python functions that send HTTP ‘GET’ and ‘POST’ requests to different API endpoints.



Backend Infrastructure

File Server:

- Web server which holds image and configuration data for drawers and tools
  - Apache server chosen - best at natively serving a directory
- Single, central server can be accessed by multiple toolboxes simultaneously
  - Eliminates the need to duplicate data across every toolbox

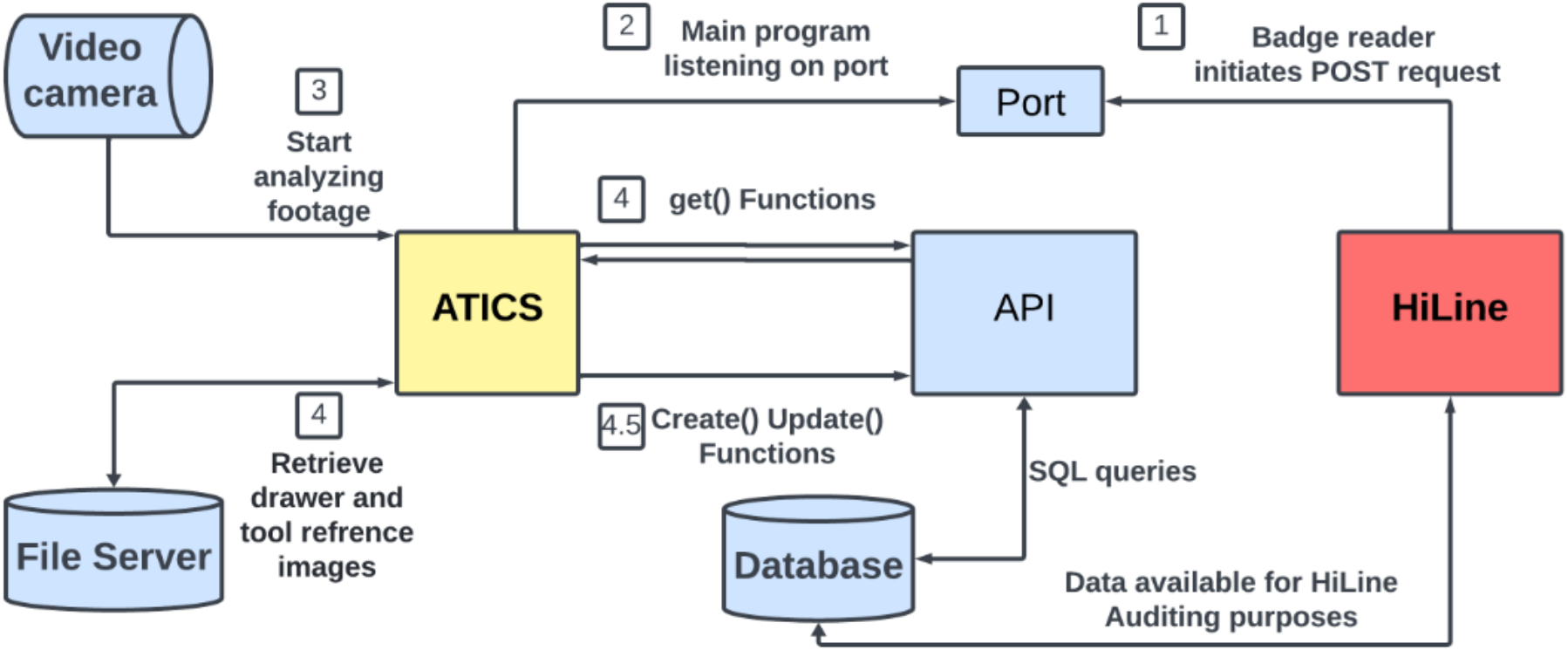


Backend Infrastructure

Architecture:

- Collection of microservices run on Docker
- Single command to start entire backend
  - `Docker compose up`
- Multiplatform - works on both Windows and Linux hosts
- Single physical server can host all services

Backend Flow Chart



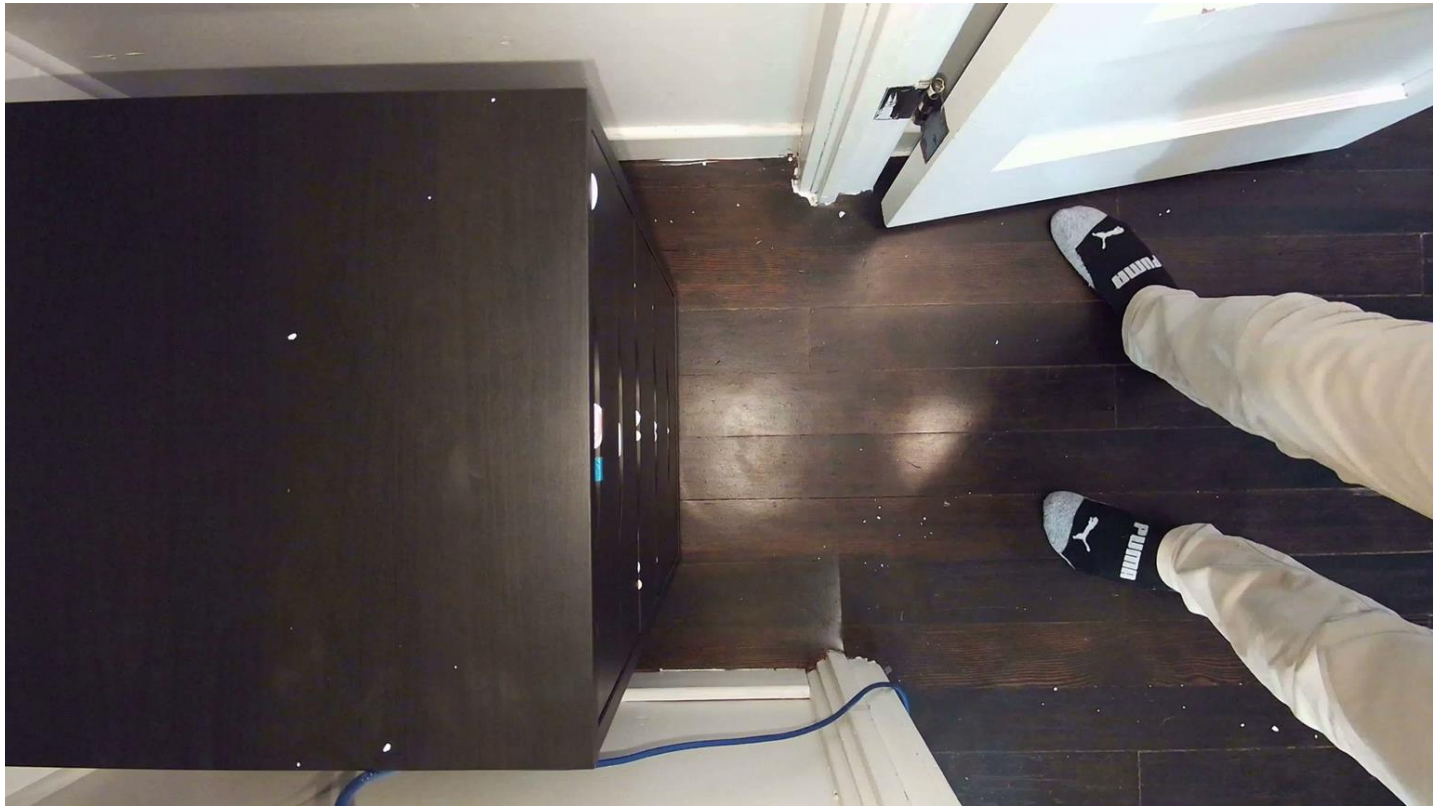
Result

Program creates:

- Bounding Box around tool and drawer displaying:
  - Name from the database
  - Status (Tool: checked out, checked in, or error)
  - Confidence percentage
- Output to the Database

Accuracy: 84%

Result - Video



Challenges

During the project, several challenges were encountered

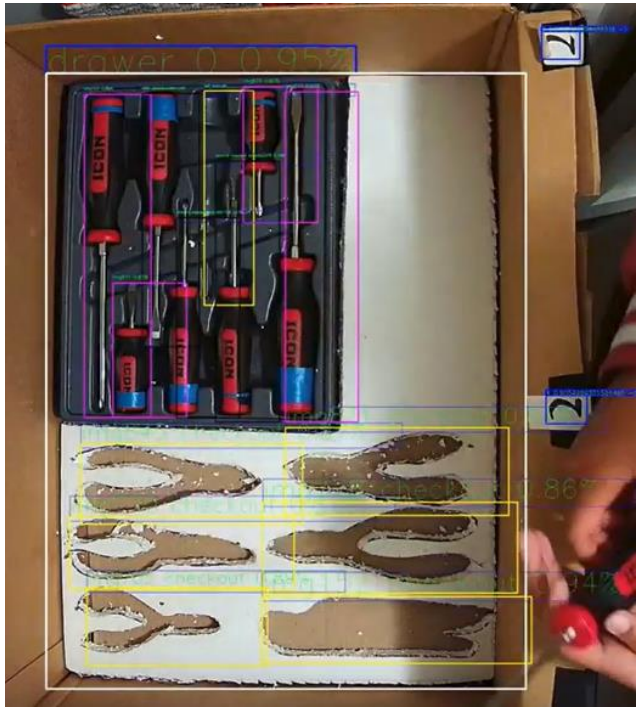
- Speed of execution
- Blurring when opening and closing the drawer
  - caused by the framerate not being high enough
- Small objects like sockets
  - difficult for computer vision to distinguish.

Future Work

- Increase speed
  - Multithread the program
  - Use specialized hardware to improve speed.
- Restrict small objects like sockets to the drawer closest to the camera.

Questions?

Initial testing setup



Example of a good template vs a bad template