Monitoring of 3D printing using machine vision

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Solution:

Edge device (Raspberry Pi 5) can communicate with **external PC/Server** where the inference is computed.

Prediction system uses **YOLO model** trained on custom dataset and **G-code visualization** to compare the current state of the printed object.

Discord bot delivers realtime notifications about the state of printing process. It also allows users to control the print remotely using /commands, if they have the right permission to do so.

Motivation:

Open Space at VUT FIT

Currently there is not any monitoring system at Open Space. Cameras are just providing **live preview** at Discord server.

Problems:

3D printing is prone to **unpredictable failures** like spaghetti effect, stringing, bed adhesion loss or extrusion defects.

The cost of the problems:

3D Printer can be damaged,
users are unstatisfied,
materials and our time is wasted!

THE GOAL:

Developing a **low-cost system** upgrading the current workflow in Open Space providing live preview with **automated error detection**, remote control for the printer and notifications for users when anything happens.

Schema:

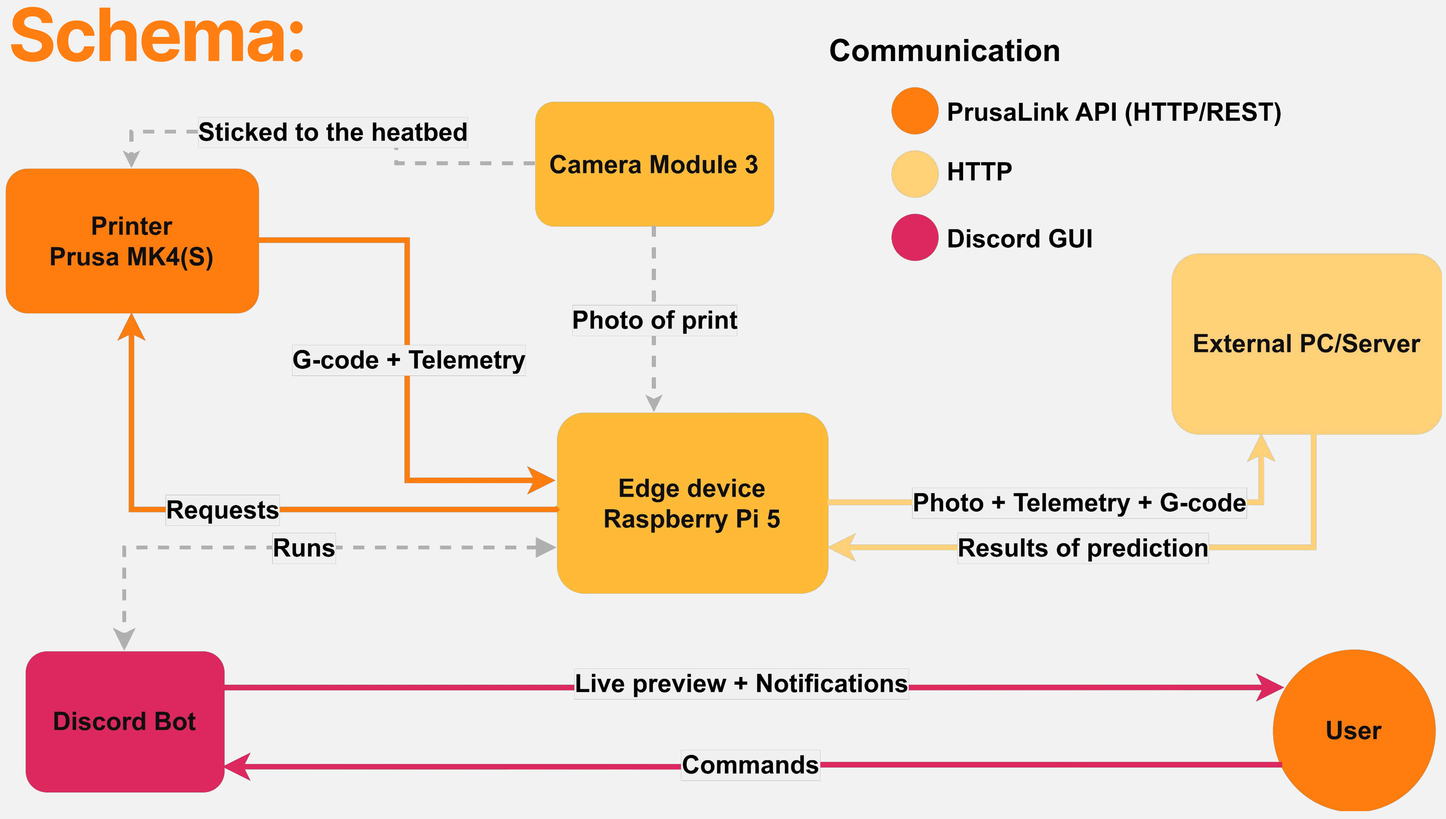


Figure 1: Block diagram

Used technologies:

OpenCV, PyVista, NumPy, HTTP, ultralytics, FastAPI, roboflow, runpod

Pipeline:

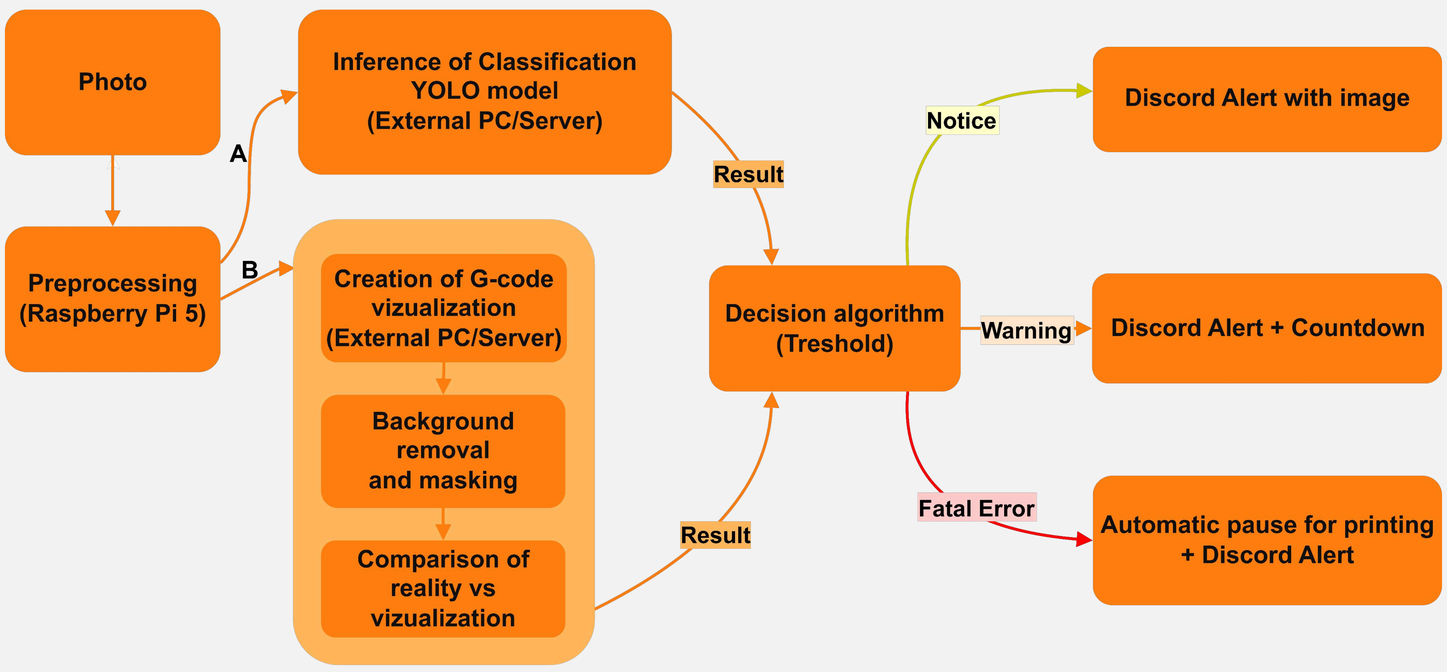


Figure 2: Pipeline of the Error detection

Discord UI:

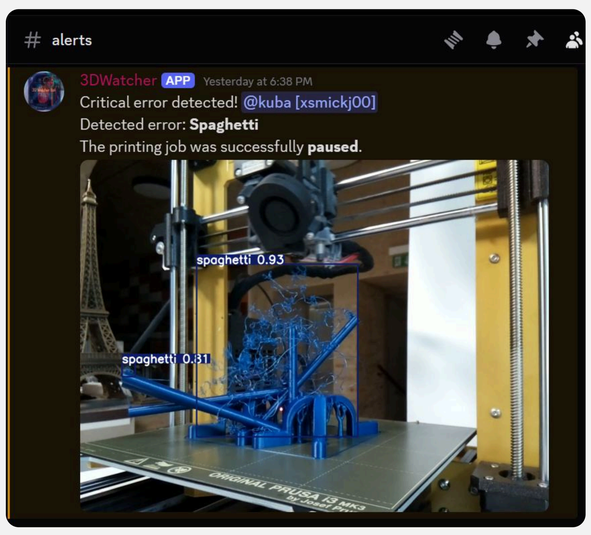
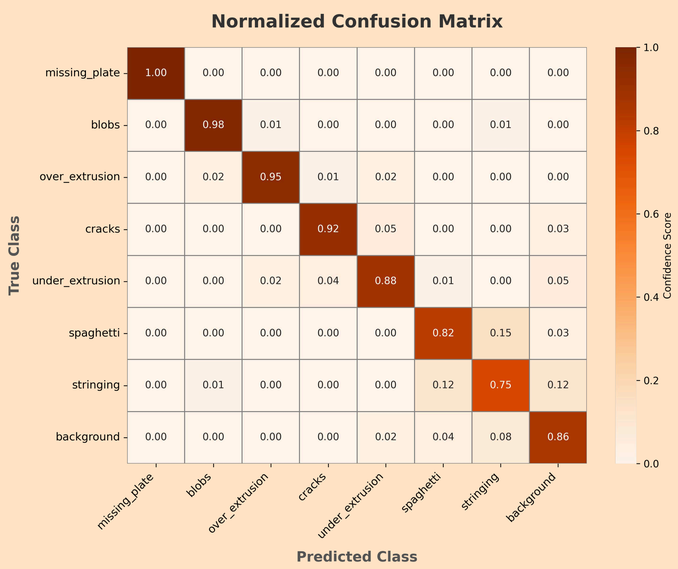


Figure 3: Example of Discord Alert

- **Commands** available for Discord users:
  - Info/Pause/Stop/Mute
  - Test_yolo/Toggle_ghost
  - Progress
  - Stream_start/Stream_stop
- **Role-based access** control (RBAC) restricts printer management to administrators and verified G-code authors

Results:

- **Dataset** of **7000+** annotated images
- **Defect classes** for classification:
  - Spaghetti effect
  - Stringing
  - Over/under extrusion
  - Blobs
  - Cracks
  - Missing plate
- **YOLO mAP50** score: 0,89
- **YOLO mAP50-95** score: 0,62
- **YOLO Precision** score: 0,89
- **YOLO Recall** score: 0,85
  - Model used: YOLO26 (Small)
  - Trained on: RTX 4090 (RunPod)



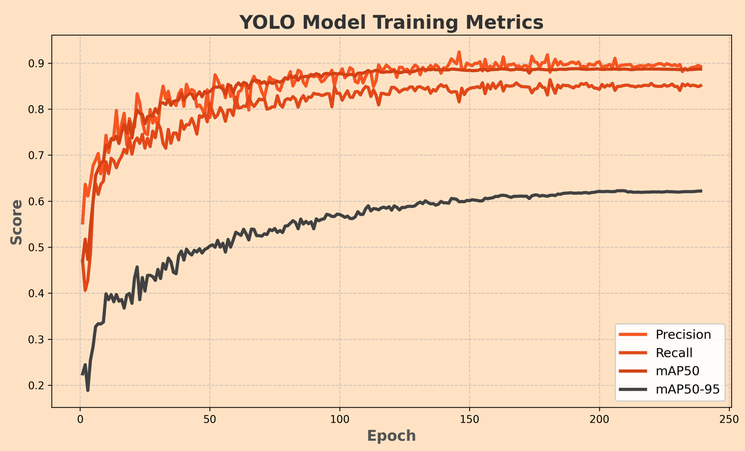


Figure 4: Confusion matrix of trained model and training metrics

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