CO-design of edge intelligence and autonomous guided vehicle Control

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INTRODUCTION 01

Current Situation

Modern manufacturing industries have many challenges

Increased customer demand

Need for efficiency and productivity

Cost control

Solution Edge AI

Recently artificial intelligence (AI) has been used to automate tasks.

In particularly, use of edge-AI has become popular.

We present a codesign of edge intelligence with automated guided vehicles.

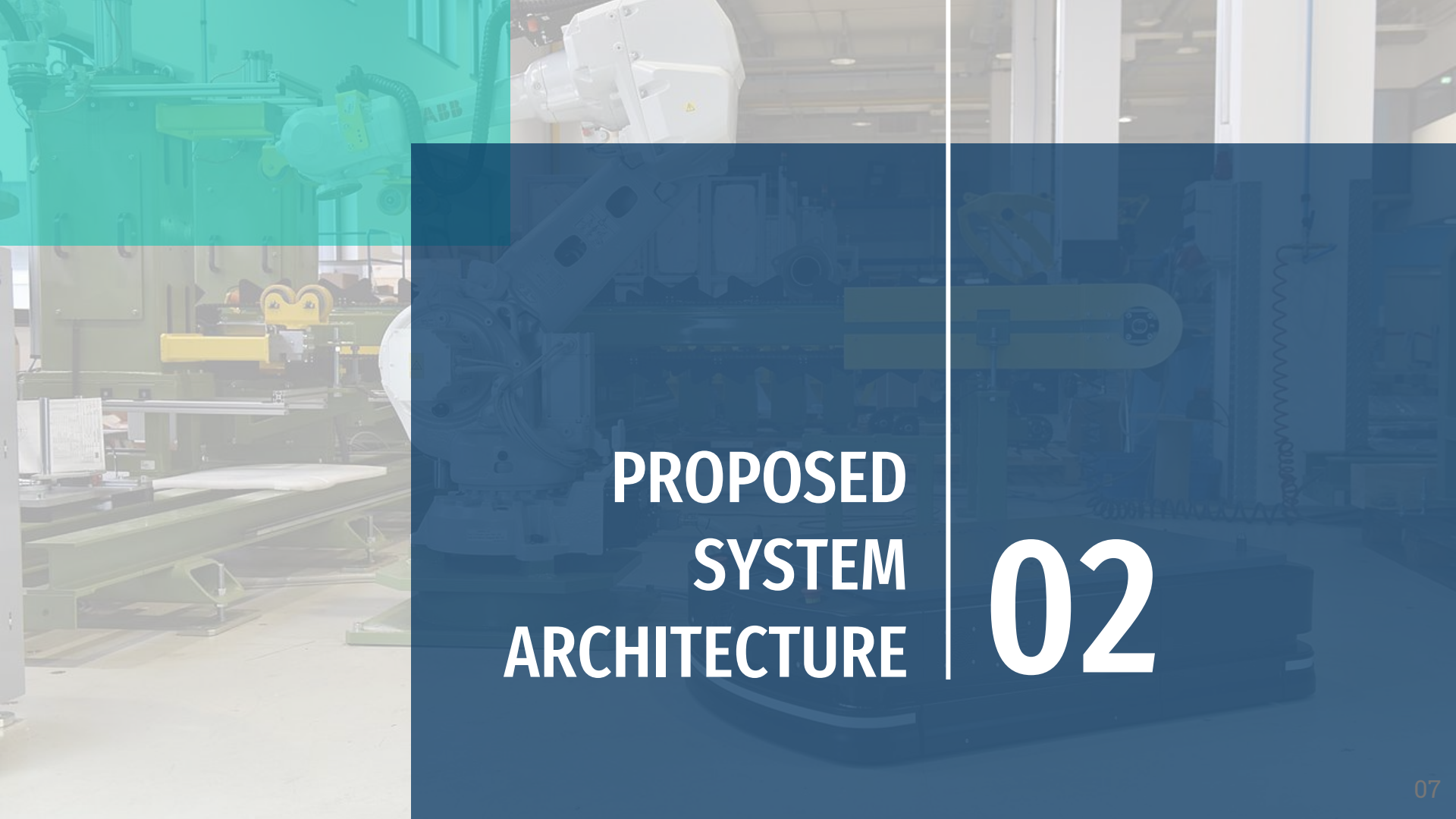
The maximum benefit of AI can be harnessed by coupling with other technologies.

Research Problem

Evaluate the applicability of edge AI and other complementary technologies.

A conceptual design to demonstrate the capabilities of edge AI, autonomous guided vehicles (AGV) and human-in-the-loop (HITL) systems.

Implement a robust system for the demonstration.



PROPOSED SYSTEM ARCHITECTURE

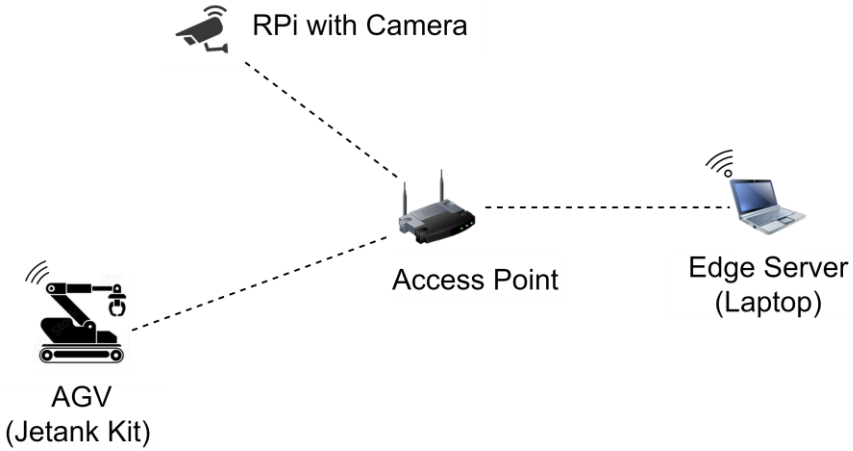
02

The proposed system architecture consists of three main hardware components

- A crawler robot (Jetank kit)
- A camera connected to Raspberry pi
- An Edge server with AI capabilities

Two main software components

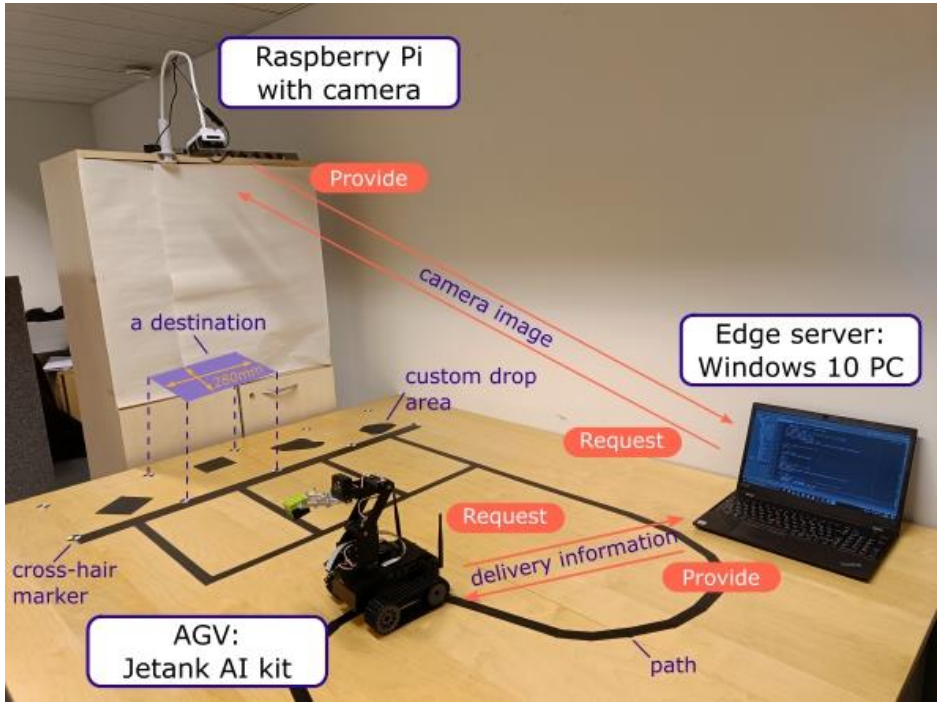
- Intelligence for navigation (on AGV)
- Intelligence for object placement (on Edge server)



- The use-case is a warehouse management scenario.
- The AGV must deliver objects.
- Preferences are set by a human.
- There are 4 delivery areas. Custom shapes are placed.
- The exact drop point is the center point of the maximum inscribed circle of each shape.
- This ensures the placed object has maximum distance from each of the edges in that shape.

03 SYSTEM DESIGN AND IMPLEMENTATION

Actual implementation of the robot platform



Intelligence for Navigation

Line-following robots are popular due to the ease of use and robust operation.

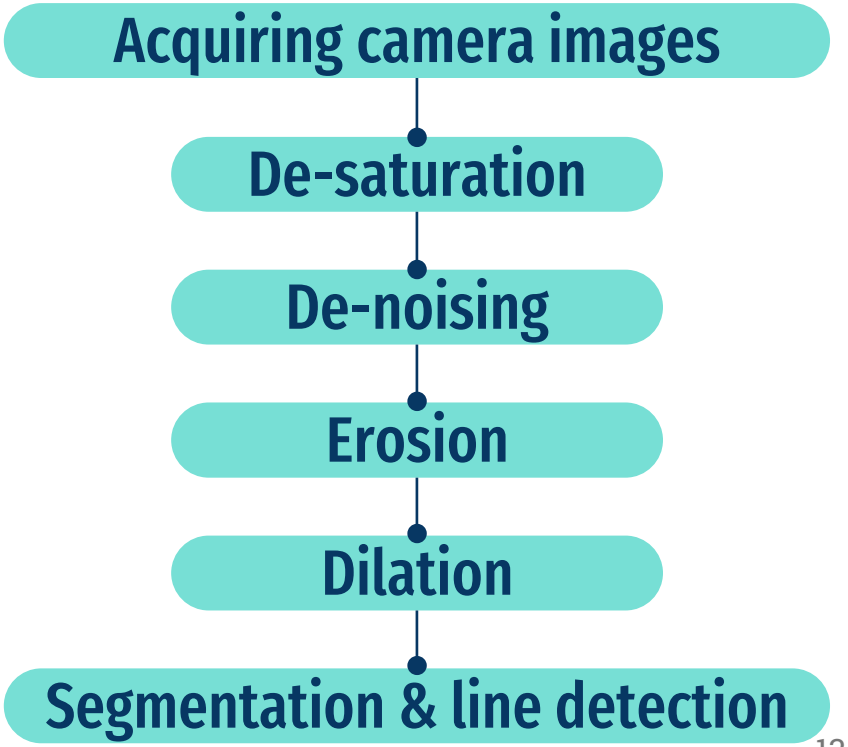
A vision-based line following system is implemented.

Reason: Ease of implementation and replication in other settings.

Vision-based line-following

- Acquiring camera images
- Image pre-processing and line detection
- Actuating control decisions of the AGV.

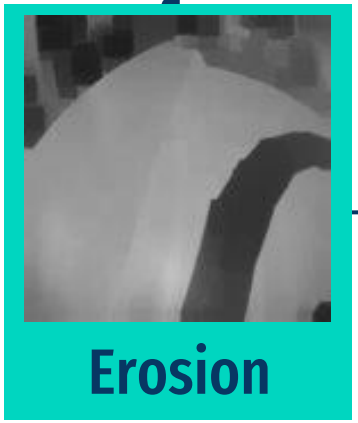
Key steps of line detection

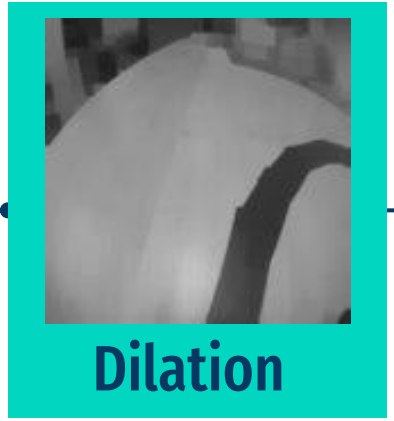



Raw image


De-saturation


De-noising

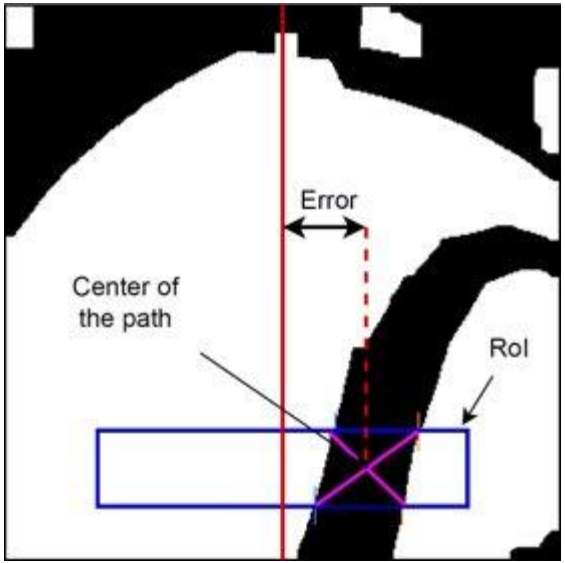

Erosion


Dilation


Segmentation

Control decisions of the AGV

- A proportional-integral-derivative (PID) controller has been used to derive control commands of the AGV.
- PID controllers are widely used in the industrial process control systems.
- Using a PID controller in the AGV ensures smooth and robust navigation along the black color paths.



A region-of-interest (RoI) is defined.

The centroid of the RoI is calculated.

The error is calculated.

A correction was applied based on the error.

Intelligence for object placement

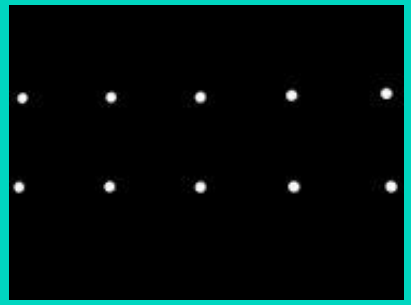
An AI service is deployed on the edge server.

AGV send s a requests before picking up the object.

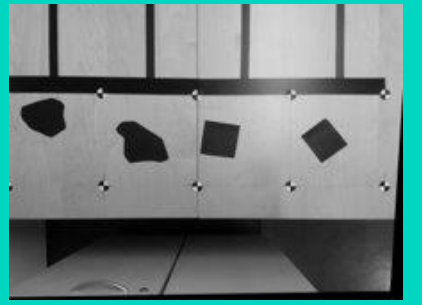
Raw images are acquired from Raspberry pi camera.

Edge server derives the center coordinates.

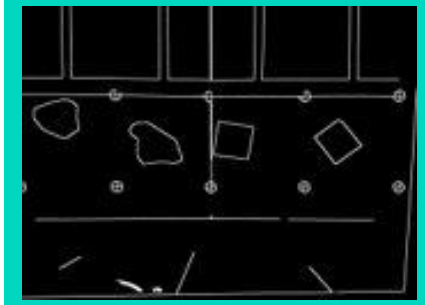
Raw image



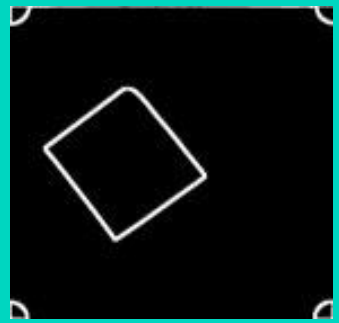
Detected markers



Distortion correction



Edge detection



Isolate the destination

Center coordinates

Cross-hair marker detection model

A U-net architecture was used.

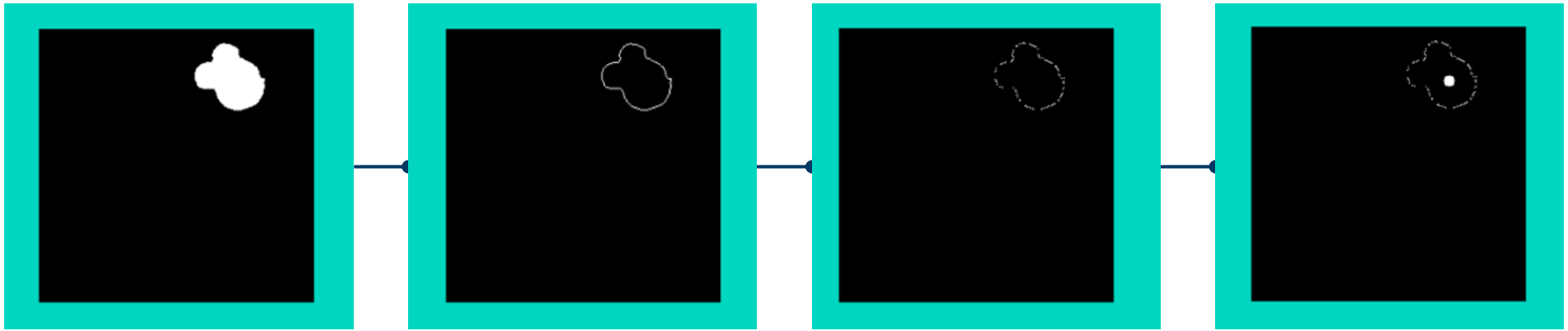
Then the model was trained.

Data augmentation procedures were adopted.

Then random samples and labels were extracted .

A master sample and a label was created.

Steps associated with detecting cross-hair markers



Predicted label

Contour

Polygon approximation

Center points

Cross-hair markers are used to isolate the destination.

Isolated region is further processed.

Center points are calculated.

Coordinates are translated.

The process is repeated.

CONCLUSION AND FUTURE WORK

04

Conclusion

A proof of concept to illustrate how co-design of edge intelligence and AGV can be utilized to automate repetitive tasks with the use of HITL.

The demo in action can be seen from:
https://youtu.be/DhCSCCZbuHo

The software related to this work can be found from:
https://github.com/ICONgroupCWC/Demo.Percom23

Future Work

Surrounding lighting conditions such as over/under exposure, harsh shadows directly impact the AGV.

To improve overall performance, brightness and exposure correction methods and deep learning models for de-noising are to be investigated in the future.

Further, obstacle avoidance of the AGV using deep learning models to investigated in the future.

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06 REFERENCES IN THE THESIS

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Thank You!

Questions are welcome

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