Codesign of Edge Intelligence and Automated Guided Vehicle Control

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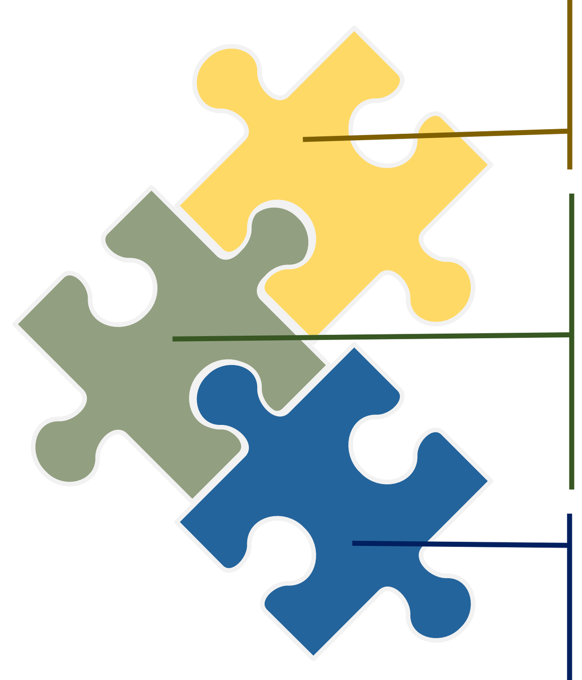
Malith Gallage, Rafaela Scaciota, Sumudu Samarakoon and Mehdi Bennis
Centre of Wireless Communications, University of Oulu, Finland

INTRODUCTION

Realization of fully/semi-autonomy in smart logistics requires the fusion of computing, communication, and control. Towards this goal, this work demonstrates an exemplary **intelligent transportation** in an industrial environment by using an **autonomous guided vehicle (AGV)** equipped with a robotic arm for a **transportation** of an object with the **aid of intelligent edge service** under **specifications defined by a human operator**.



AGV Navigation
- Handles & transports objects
- Uses a custom-defined path

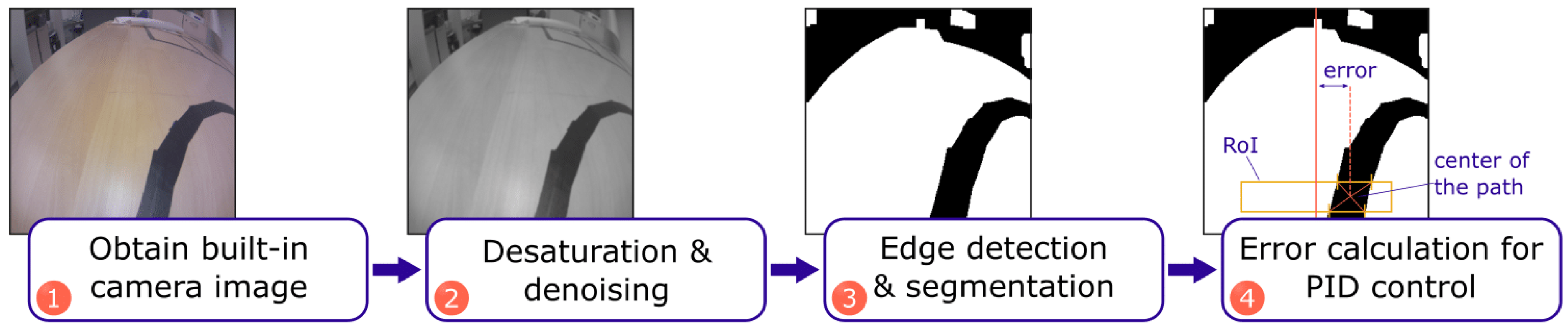
Human-in-The-Loop (HITL)
- Defines drop area with custom shapes
  - Drop-point: center of the drop area
  - *Delivery information*: Destination & Drop-point

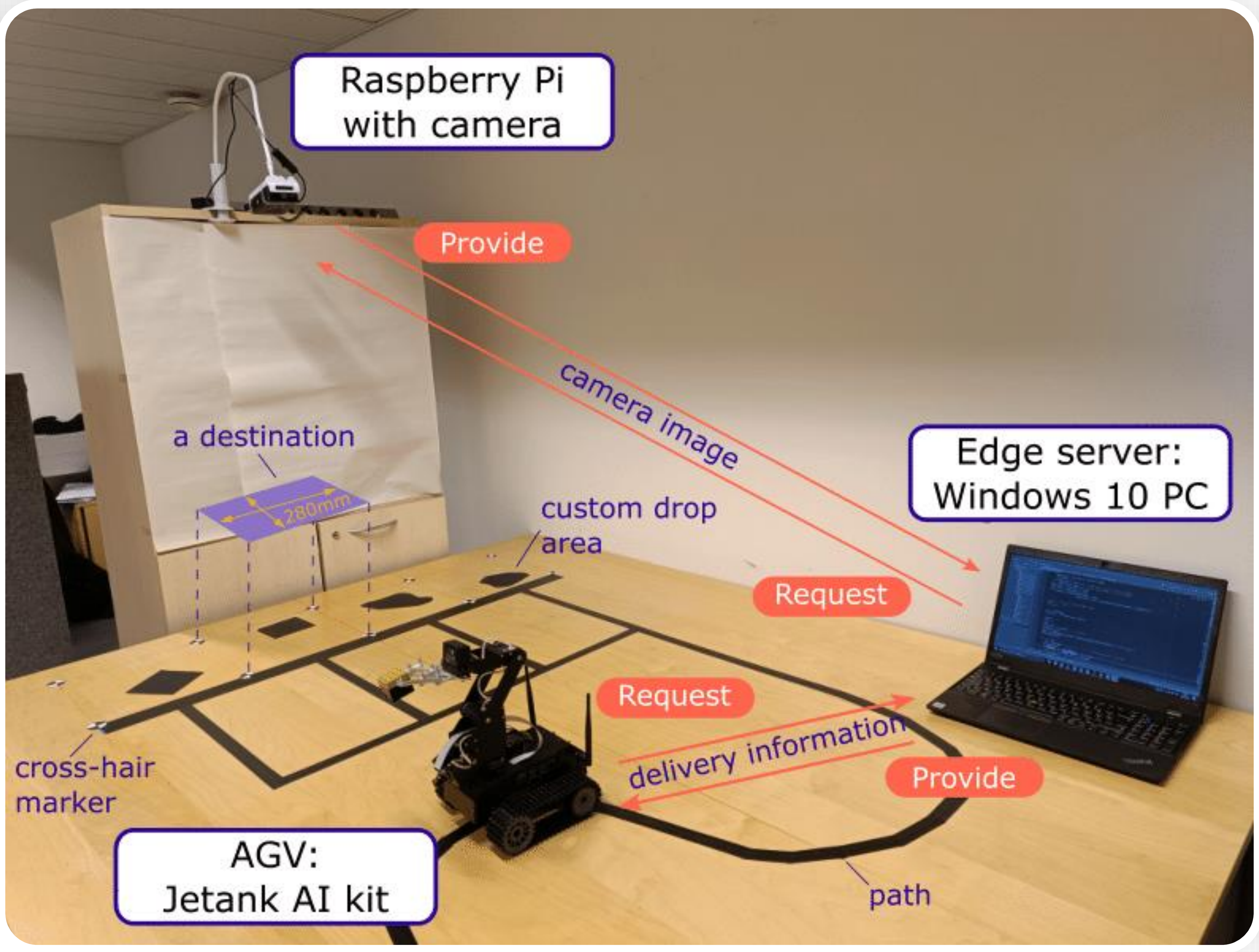
Edge Intelligence
- Observes destinations
- Computes drop-point
- Sends delivery information to the AGV

INTELLIGENCE FOR NAVIGATION

A vision-based line following system that uses a PID controller is implemented on the AGV to successfully navigate around the platform.

- A 3 × 3 Gaussian kernel is used for denoising (step 2).
- OTSU [1] method is used for image segmentation (step 3).
- A *region of interest (RoI)* is defined to separate path from undesired black areas (step 4).





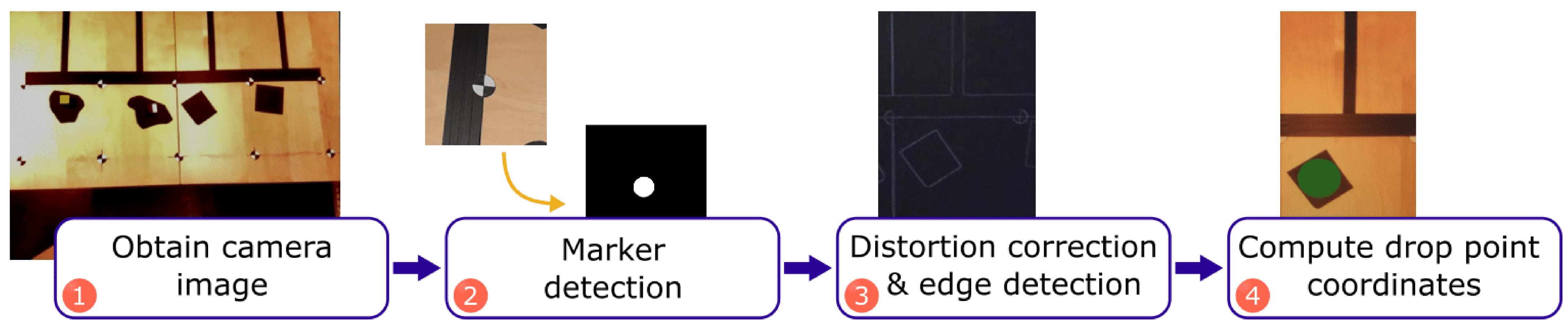
HARDWARE

- AGV is the "*Jetank AI kit*" including a *Nvidia Jetson nano* developer module with 16GB eMMC and 4GB RAM [3].
- AGV is equipped with 4-DoF mechanical arm and a wide-angle camera with 160◦ field-of-view.
- The destinations are monitored with a *Raspberry Pi (RPi) V2* camera module that connects with a *RPi 4 Model B* computer.
- A multi-purpose *64-bit Windows 10* computer acts as the edge server.

INTELLIGENCE FOR OBJECT PLACEMENT

The edge server provides intelligence in computing the delivery information.

- A machine learning model with U-NET architecture [2] is used to detect cross-hair markers, and thus, the four destinations.
- Custom drop areas in destinations are detected utilizing OTSU method.
- Drop point is the center of the largest circle placed in the custom drop area.



Resources:
https://github.com/ICONgroupCWC/Demo.Percom23

Video:
https://youtu.be/DhCSCCZbuHo

REFERENCES

[1] N. Otsu, "A threshold selection method from gray-level histograms," IEEE Transactions on Systems, Man, and Cybernetics, vol. 9, no. 1, pp. 62–66,1979.
[2] O. Ronneberger, P. Fischer, and T. Brox, "U-net: Convolutional networks for biomedical image segmentation," in Proc. of Intl. Conf. on Medical image computing and computer-assisted intervention. Springer, 2015, pp. 234–241.
[3] Waveshare, "Jetank ai kit," Available at https://www.waveshare.com/jetank-ai-kit.htm (2022/11/11).

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