

Development of a Method for Detecting the Orientation of Parcels in Container Unloading Processes

Mahdi Islam

Matriculation Number: 3168896

Faculty: Mathematics/Computer Science (FB 03)
Digital Media (Media Informatics)

Primary Supervisor

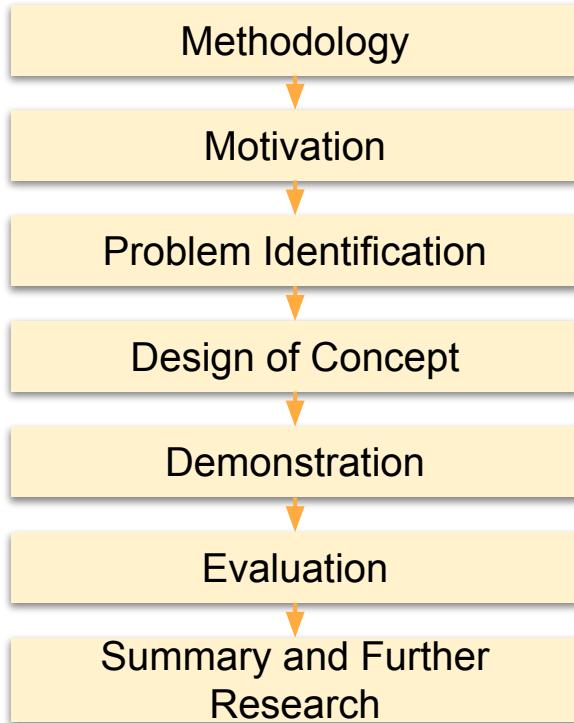
Prof. Dr Hans-Jörg Kreowski
University of Bremen, Department of Computer Science
D-28334 Bremen
Tel.: +49 421 218 64451
email: kreo@uni-bremen.de

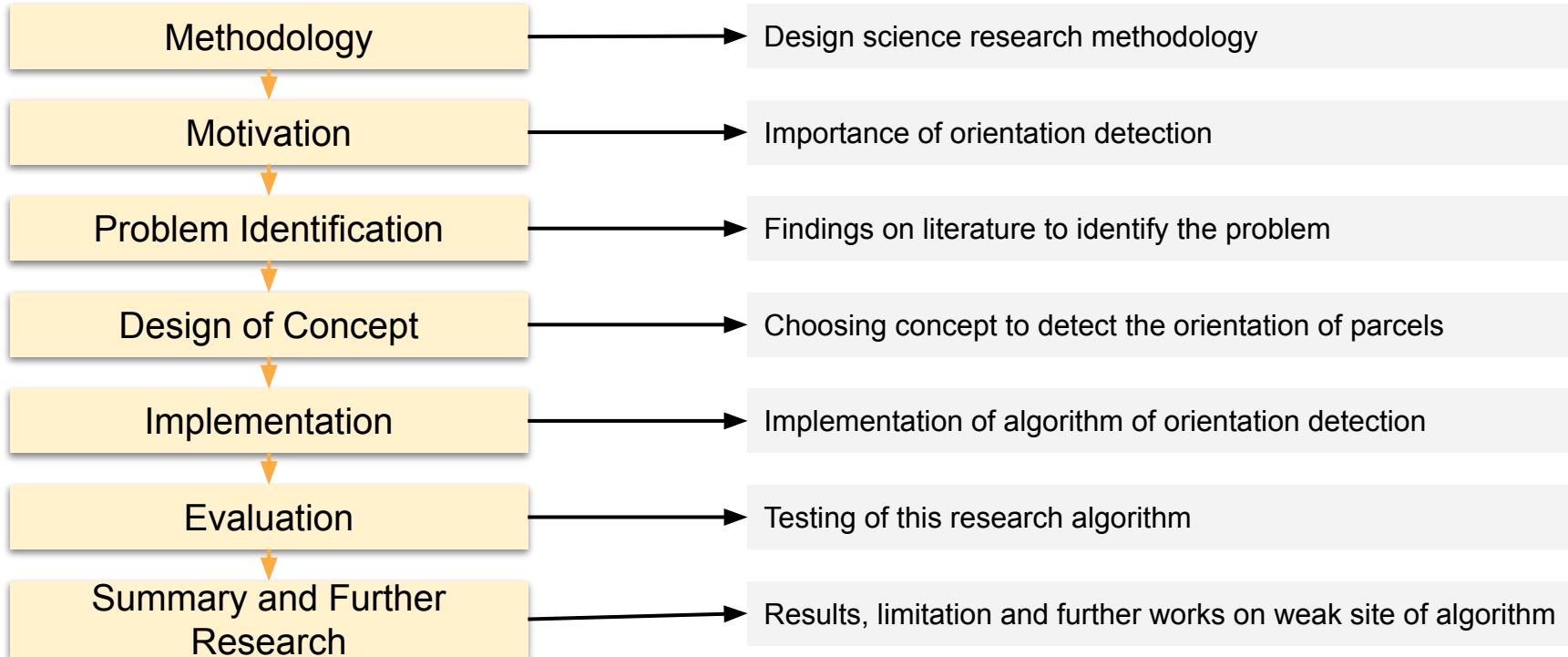
Secondary Supervisor

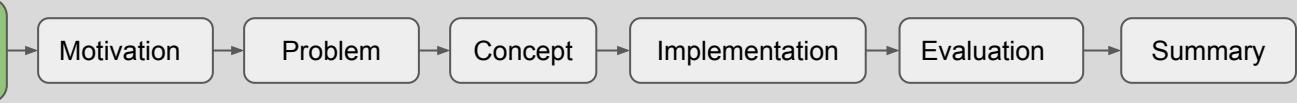
Prof. Dr.-Ing. Thies Beinke
BIBA - Bremen Institute for Production and Logistics GmbH
Hochschulring 20, 28359 Bremen
Tel: +49 (0) 421 / 218-50086
email: ben@biba.uni-bremen.de

Advisor

Christoph Petzoldt
BIBA - Bremen Institute for Production and Logistics GmbH
Hochschulring 20, 28359 Bremen
Tel: +49 (0) 421 / 218-50119
email: ptz@biba.uni-bremen.de







Design Science Research Methodology

- Creation of an artifact
- Analysis of solution
- Learning by building

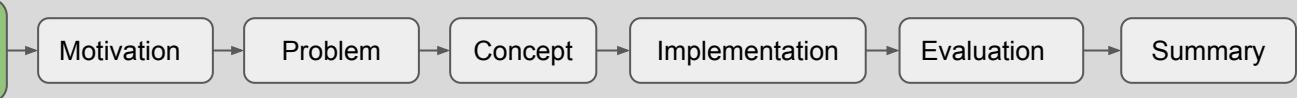


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Proposed Framework

- Hevner (2004) divides the design science research process into 3 cycle.
- Peffers (2007) proposed 6 steps to the design science research(DSR) process.



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Henver (2004) Framework

- The Relevance Cycle
- Rigor Cycle
- Design Cycle

Methodology



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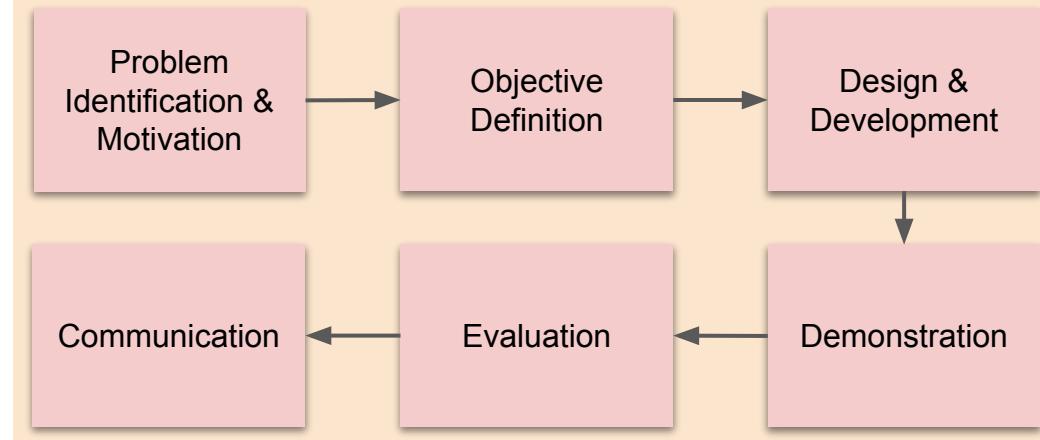
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Used Framework- Peffers (2007)



Automatic Unloading System



Figure 01: Manual unloading system (01).

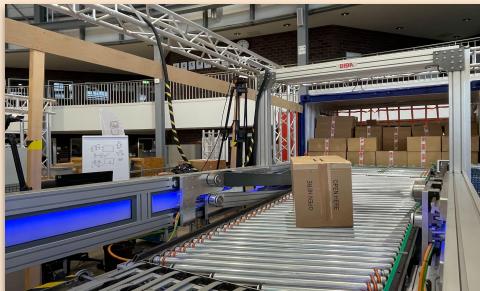


Figure 02: Automatic unloading system.

Automatic Unloading System



Figure 01: Manual unloading system (01).

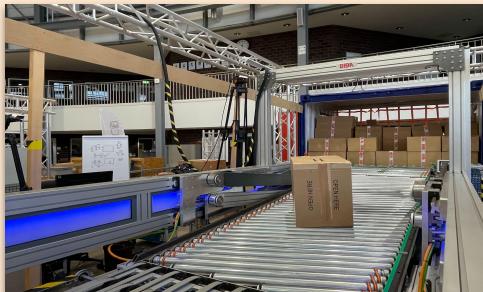


Figure 02: Automatic unloading system.

Orientation Detection of Parcels



Figure 03: Scan barcode and unfit large parcel (02).



Figure 04: Store parcels after unload (03).



Figure 05: Understand the aspects for robot (04).

Literature Review

Template Matching

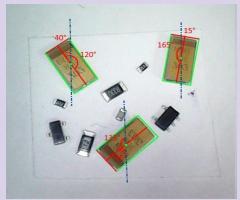


Figure 06: Detect orientation by template matching method (05).

Monocular Orientation Estimate

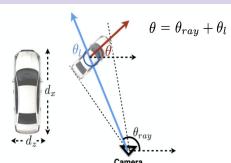


Figure 07: Detect global orientation (06).

Binary Classifier

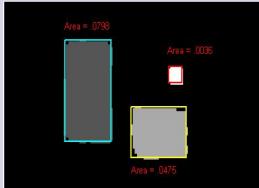


Figure 08: Calculation of area for object (07).

Central Based

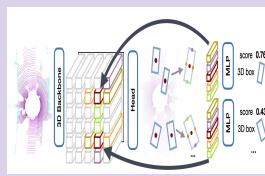


Figure 09: Detect orientation by calculation of center of objects (08).

BBAVectors

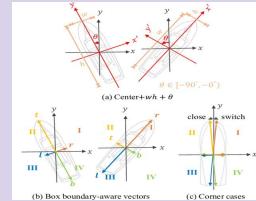


Figure 10: Orientation of bounding box (09).

MediaPipe



Figure 11: Object detect by color segmentation (10).

Literature Review

Template Matching

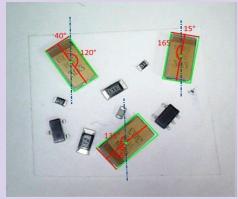


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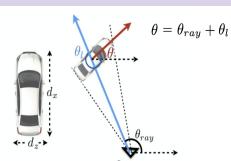


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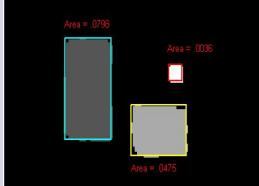


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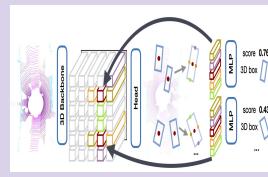


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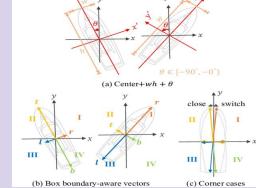


Figure 10: Orientation of bounding box (09).

MediaPipe



Figure 11: Object detect by color segmentation (10).

Research Question

- How to extract information regarding the rotation of logistic packages in a real-time autonomous container unloading system using a combination of deep learning and statistical aspects of parcels?
- Is there any effect on the orientation detection processes due to parcel and environmental characteristics?



Feature of parcels

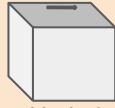
- ❖ Size of parcels
- ❖ Arrow marks
- ❖ Color of parcels (Bourbon)
- ❖ Fit on conveyor belt



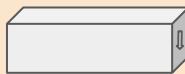
Feature of parcels

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Orientation Types



Vertical



Z-Horizontal

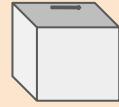


Horizontal

Feature of parcels

- ❖ Size of parcels
- ❖ Arrow marks
- ❖ Color of parcels (Bourbon)
- ❖ Fit on conveyor belt

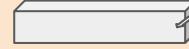
Orientation Types



Vertical

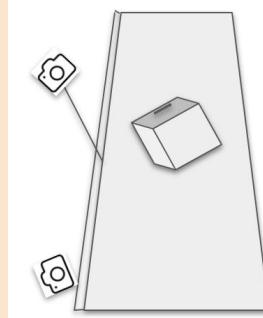


Z-Horizontal



Horizontal

Camera Settings

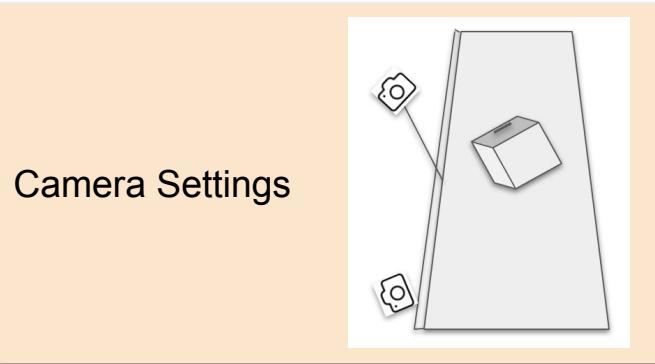
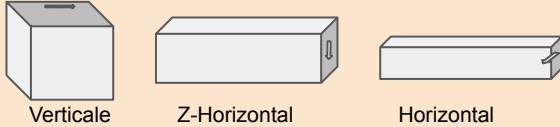




Feature of parcels

- ❖ Size of parcels
- ❖ Arrow marks
- ❖ Color of parcels (Bourbon)
- ❖ Fit on conveyor belt

Orientation Types



Camera Settings

Image Processing

Machine learning

Neural Network

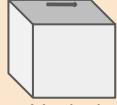
OpenCV

Pyrealsense2

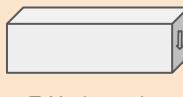
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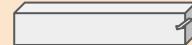
Orientation Types



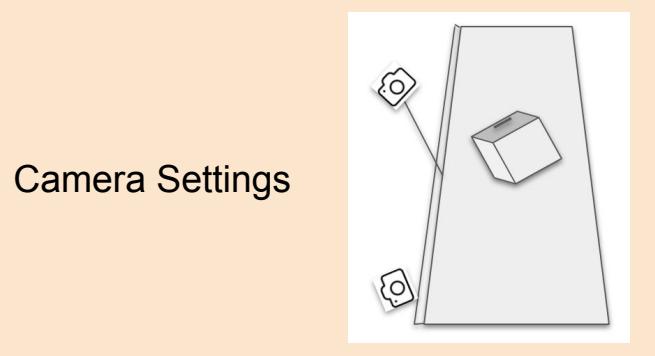
Vertical



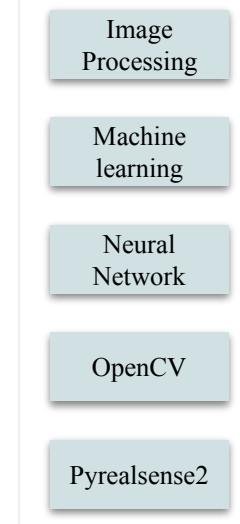
Z-Horizontal



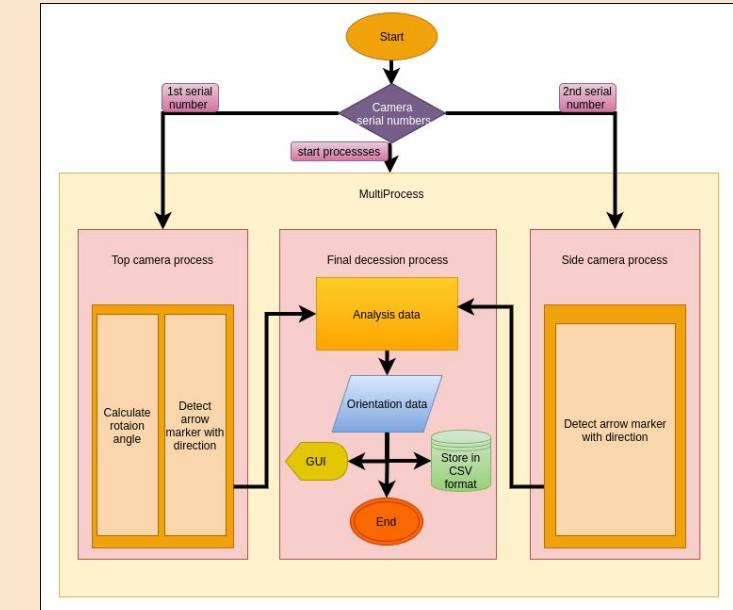
Horizontal

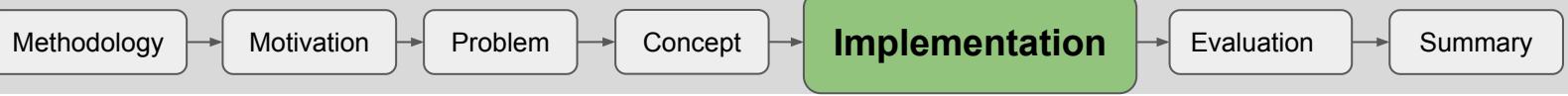


Camera Settings

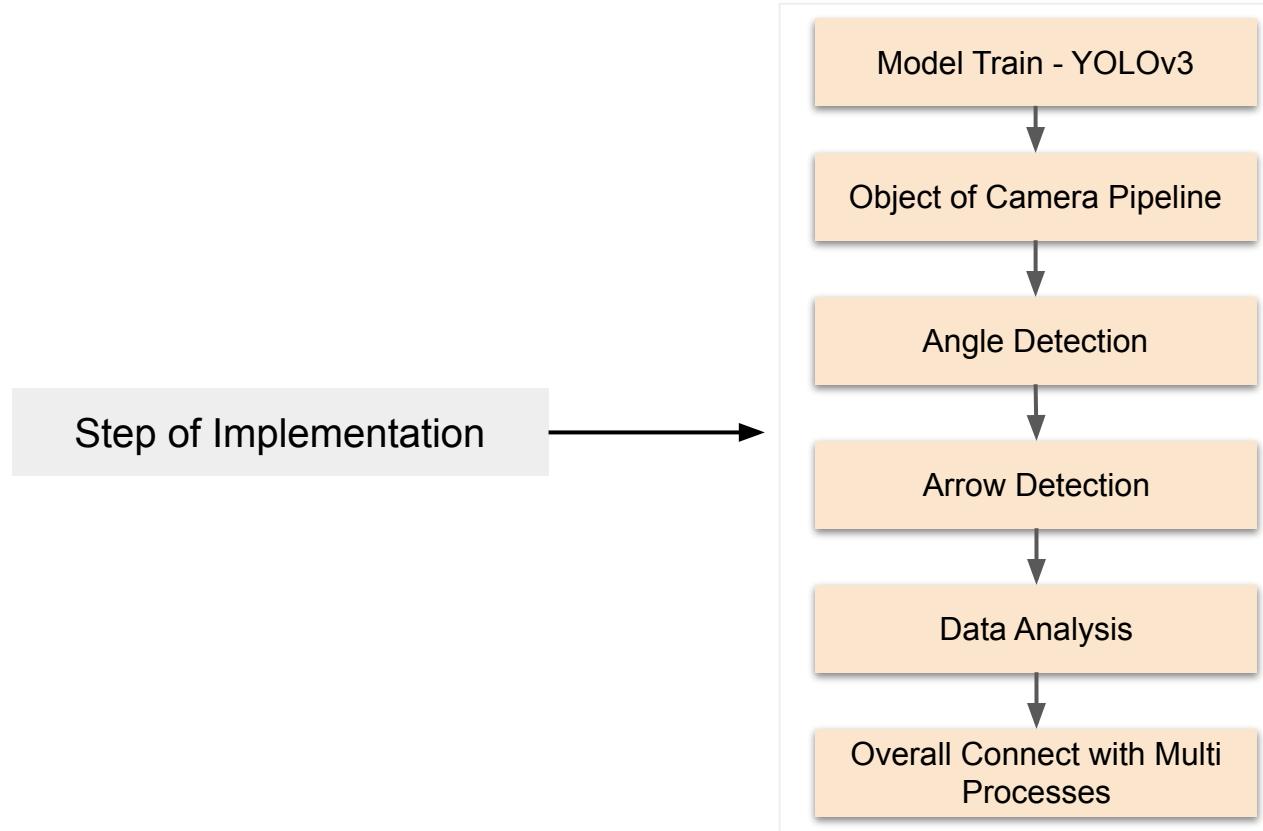
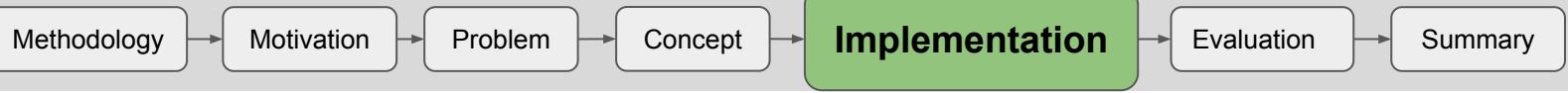


Orientation Detection Concept





Step of Implementation



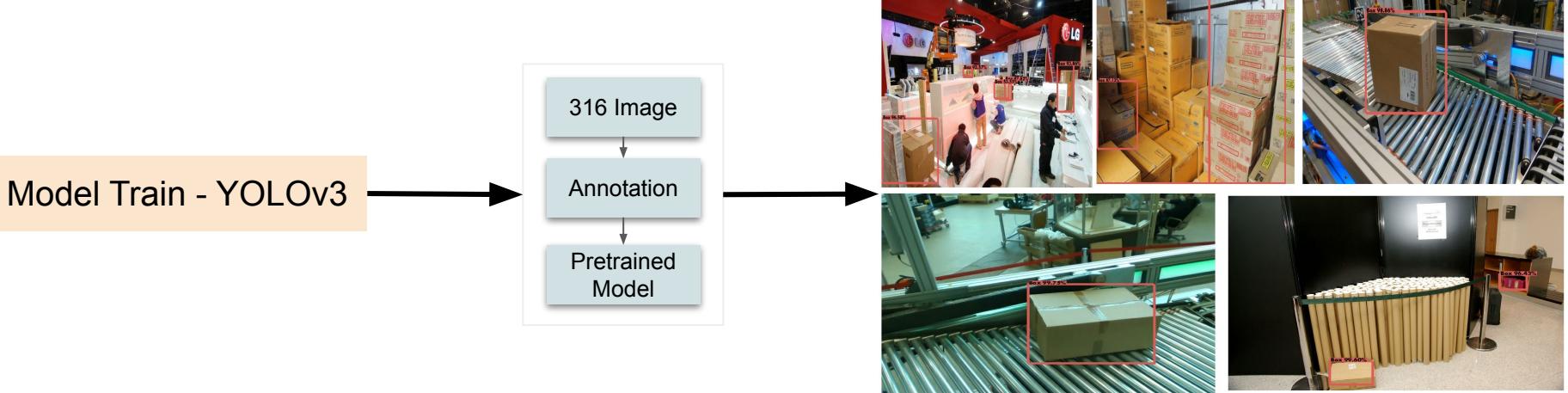
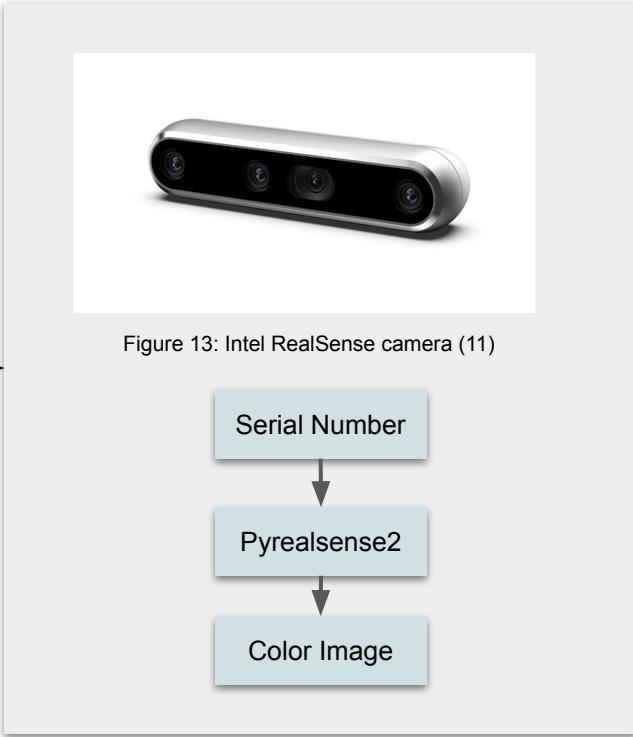


Figure 12: Test on images by this trained model. After trained the model this thesis tests on various image to predict the parcels with different size and distance between parcels. The small parcels of confidence percent is low.



Camera Pipeline
Object



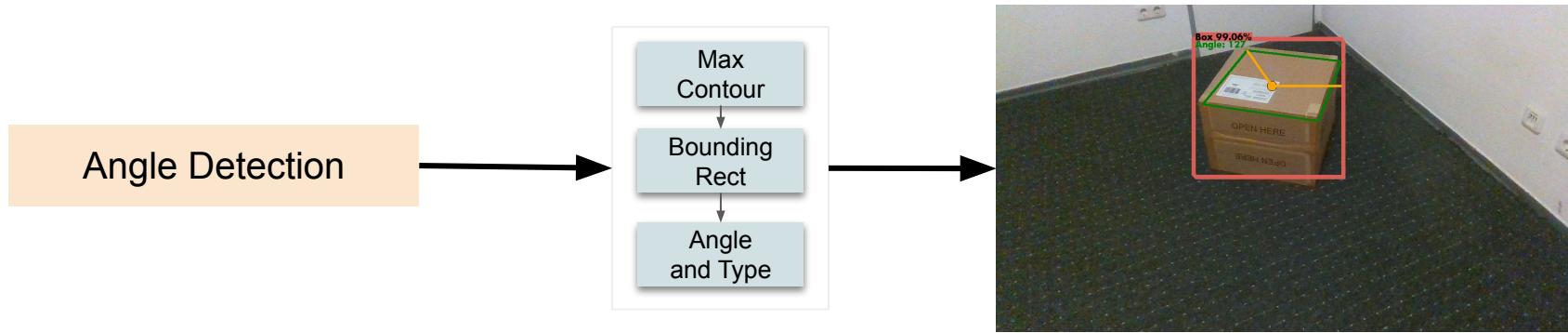


Figure 14: Output of angle detection pipeline. The rotate angle result in degree shown also display.

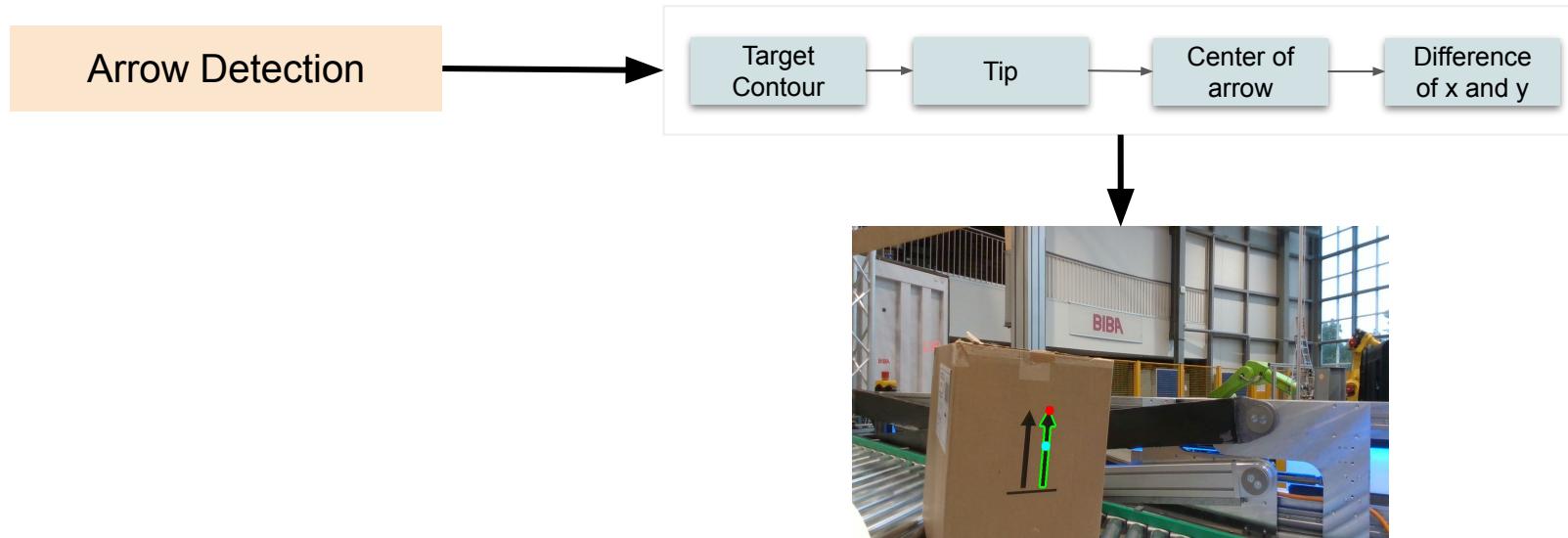


Figure 15: Output of arrow detection pipeline. Red circle is tip and green is contour and navy blue circle is center of arrow.

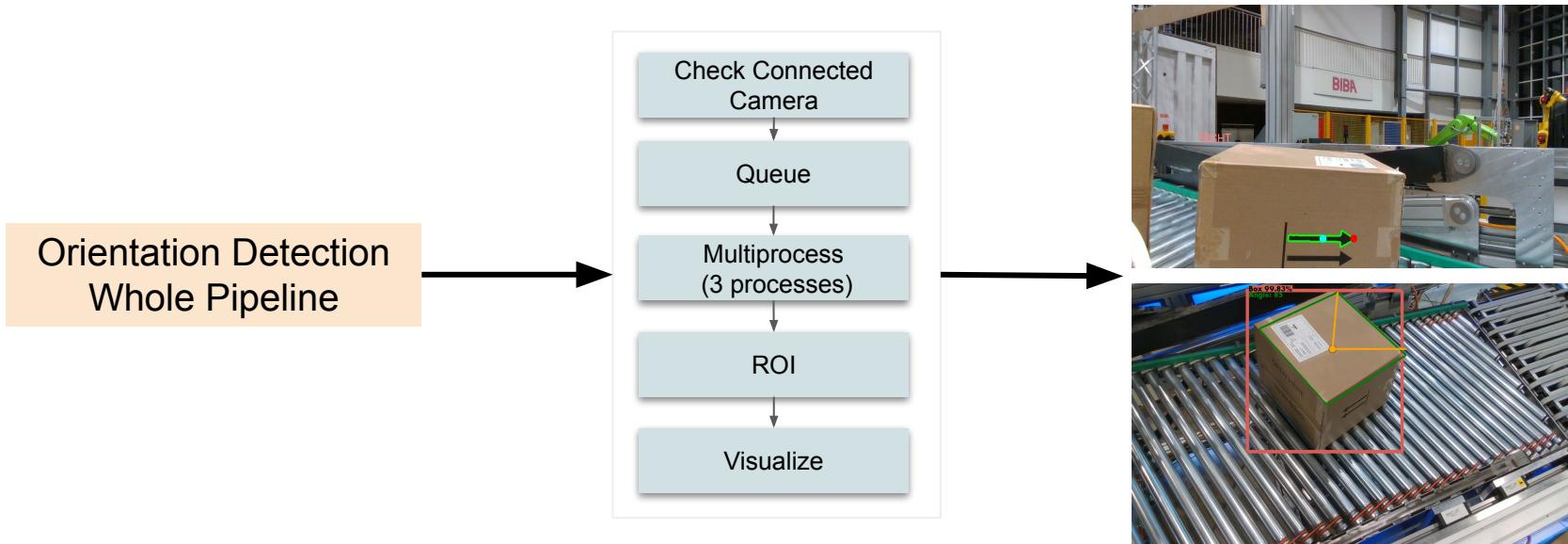
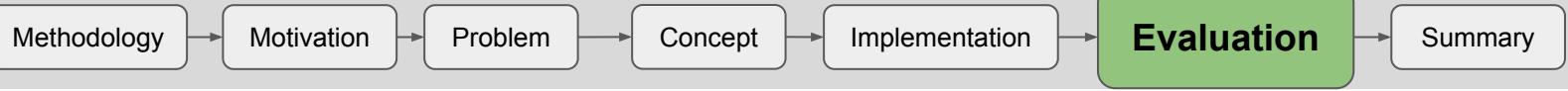


Figure 16: Detect orientation of parcels after connected all process through multiprocess.



Laboratory Test		
Number	Noise	Sizes
Colors	Distance	Lights

Field Test		
Orientations	Distance	Sizes
Speed		

Laboratory Test

- ❖ Number
- ❖ One Parcel
- ❖ Two Parcels
- ❖ Three Parcels

- ❖ Noise
- ❖ Clean
- ❖ Medium
- ❖ Hard

- ❖ Sizes
- ❖ Small
- ❖ Medium
- ❖ Large

- ❖ Colors
- ❖ Own
- ❖ Different

- ❖ Distance
- ❖ Less than 50cm
- ❖ Greater than 50cm

- ❖ Lights
- ❖ Bright Ambient
- ❖ Normal
- ❖ Ambient

Field Test

- ❖ Orientations
- ❖ Vertical
- ❖ Horizontal
- ❖ Horizontal-Z

- ❖ Distance
- ❖ Short
- ❖ Medium
- ❖ Long
- ❖ Attach

- ❖ Sizes
- ❖ Small
- ❖ Medium
- ❖ Large

- ❖ Speed
- ❖ Normal
- ❖ Medium
- ❖ High

Laboratory Test

- ❖ Number
- ❖ One Parcel
- ❖ Two Parcels
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- ❖ Noise
- ❖ Clean
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- ❖ Medium
- ❖ High

Threshold Type to Evaluate Performance



Threshold Type	Angle (Difference between actual and detection)	Arrow Position (Prediction)	Arrow Direction (Prediction)
Good	Less equal 5	True	True
Medium	Greater than 5	True	True
Bad	Greater than 5	False	False

Laboratory Test

Number

Noise

Sizes

Colors

Distance

Lights

Orientations

Distance

Sizes

Speed

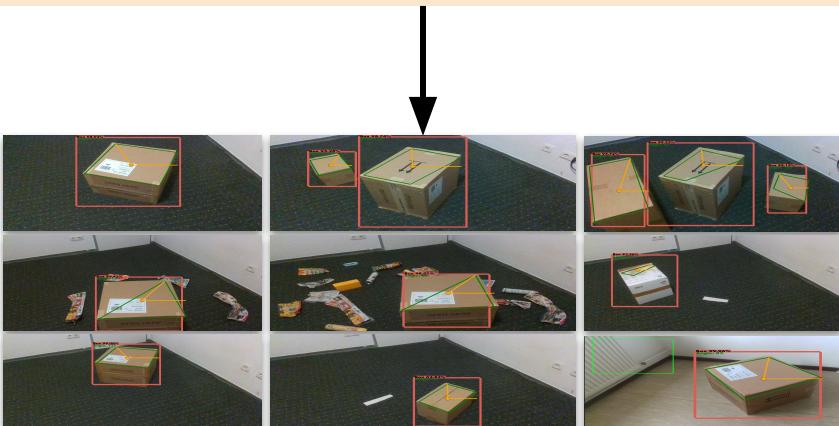


Figure 17: Orientation detection in the laboratory. The system detects the angle of parcels in a variety of situations, as illustrated in the image.

Field Test

Orientations

Distance

Sizes

Speed

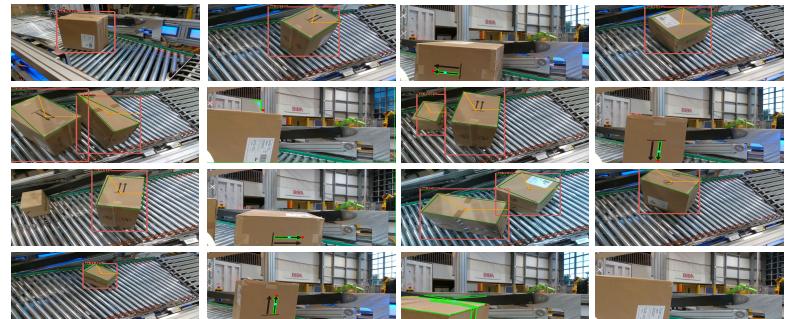


Figure 18: Orientation detection on the container unloading system. On the real unloading system, the algorithm for detecting angle and arrow is presented in several tests on the figure.

Laboratory Test (Overall)

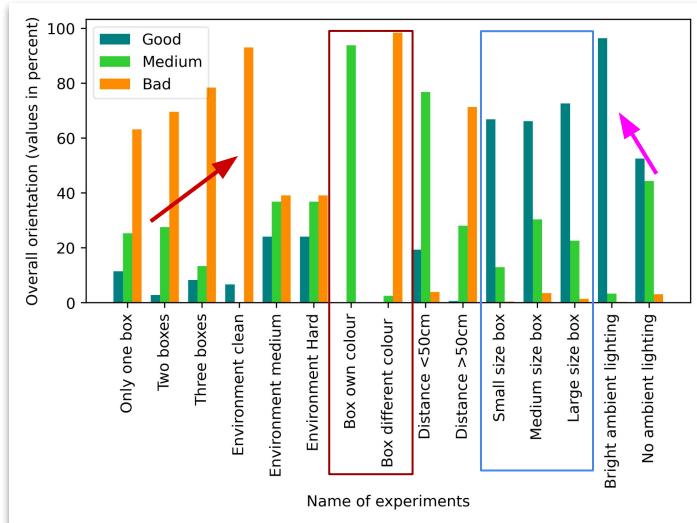


Figure 19: In several laboratory experiments, the percentage of good, medium, and bad results for detecting parcel orientation. More good percentage when there is bright ambient light than when there is no ambient light. The ability to determine the orientation of parcels is similarly influenced by distance. When compared to many parcels, the percentage of bad is smaller in exist.

Field Test (Overall)

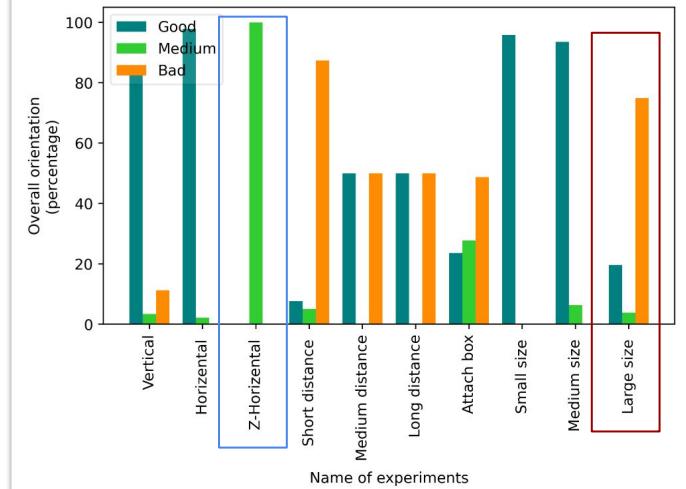


Figure 20: Detection of parcel orientation on container unloading system as a percentage of good, medium, and bad. The algorithm is not very good in the case of short distances and large parcel sizes in the unloading system.

Laboratory Test (Angle)

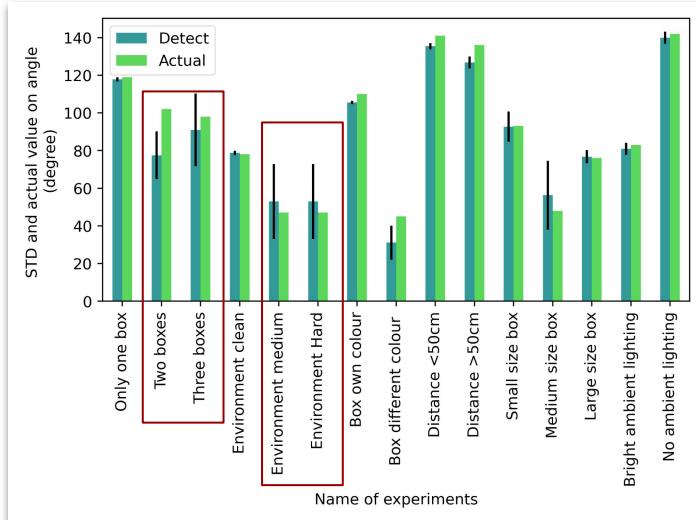


Figure 21: Comparison between detecting angle standard deviations and real angle standard deviations.

Field Test (Angle)

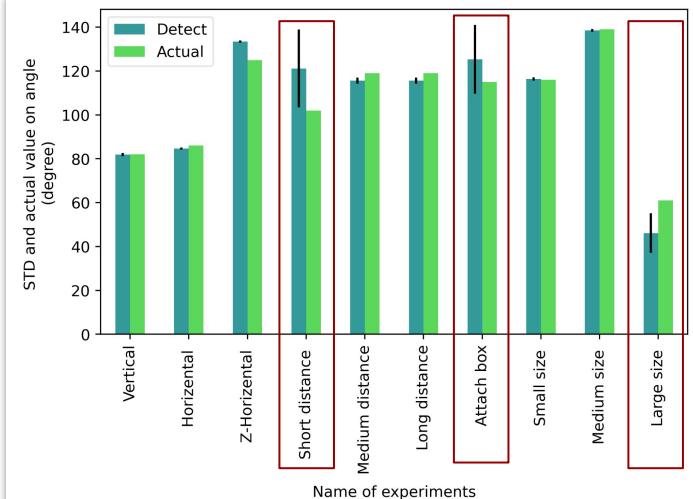
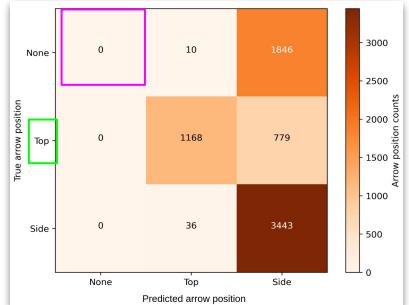


Figure 22: Comparison of detecting angle and actual angle standard deviations

Laboratory Test (Arrow)



Field Test (Arrow)

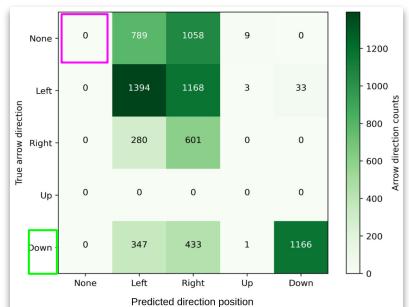
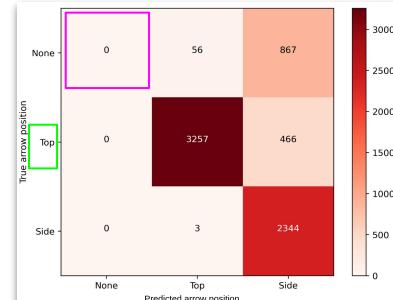


Figure 23: For all laboratory experiments, there is a confusion matrix for the arrow detection pipeline. Top position precision 0.96 and down direction 0.97.

Figure 24: For all Field experiments, there is a confusion matrix for the arrow detection pipeline. Top position precision 0.98 and up direction 0.99.

Laboratory Test (Overall)

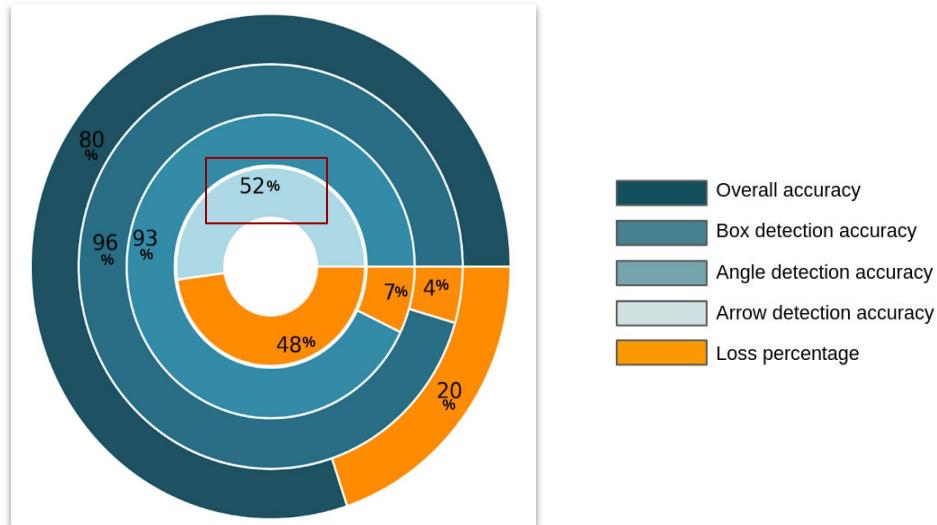


Figure 25: Laboratory test accuracy. It reveals that the orientation detecting algorithm is 80% accurate. The entire algorithm is more affected by the arrow detection process.

Field Test (Overall)

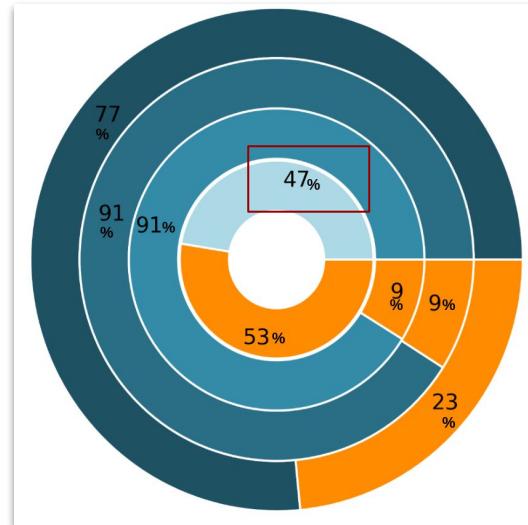
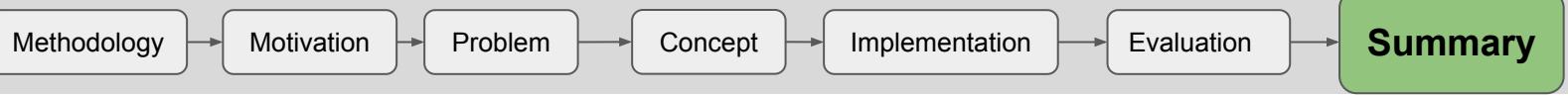
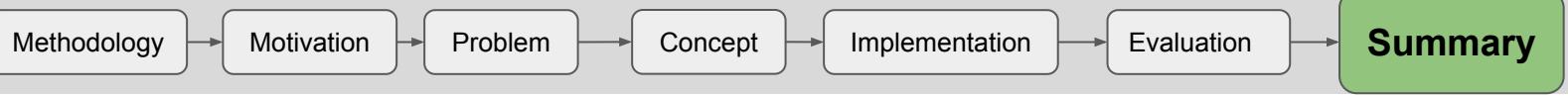


Figure 26: The field test's accuracy. The overall accuracy is 77%, with the arrow detection pipeline having the largest impact. The parcel detection model and angle detection pipeline have a strong performance, with a 91 percent accuracy.



Summary and Discussion - Orientation Detection Algorithm

- Lights
- Distance
- Color



Summary and Discussion - Orientation Detection Algorithm

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Final Accuracy 79%

Detection of Parcels

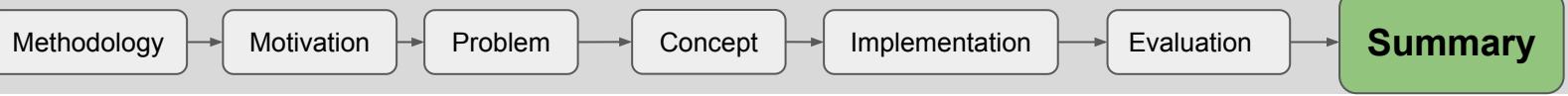
- High Accuracy
- Detect parcels in different conditions
- Accuracy 94%

Detection of Orientation

- #### Angle Detection
- High Accuracy
 - Error rate is not so high
 - Accuracy 92%

Arrow Detection

- Low Accuracy
- None is not detected
- Accuracy 50%



Summary and Discussion - Orientation Detection Algorithm

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Final Accuracy 79%

Detection of Parcels

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- Detect parcels in different conditions
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Arrow Detection

- Low Accuracy
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- Accuracy 50%

Future Work

➤ Update arrow detection pipeline

Possible Solution

- Could also count front side arrow marker implementing new color threshold to find the contours
- Could also use model to detect the arrow marker then calculate the direction

1. <https://goldenstatemh.com/services/container-unloading/>
2. <https://www.cognex.com/industries/consumer-products/distribution/automated-sorting>
3. https://www.robotics247.com/article/robot_fleets_grow_demands_warehouse_management_software_interoperability_layer
4. <https://www.cognex.com/industries/logistics/sortation/ship-sorger-induction>
5. <https://answers.opencv.org/question/179797/template-matching-find-rotation-of-object-on-scene/>
6. A. Mousavian, D. Anguelov, J. Flynn, and J. Kosecka, "3d bounding box estimation using deep learning and geometry," in CVPR, 2017.
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9. J. Yi, P. Wu, B. Liu, Q. Huang, H. Qu, and D. Metaxas, "Oriented object detection in aerial images with box boundary-aware vectors," in Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision, 2021, pp. 2150–2159
10. <https://google.github.io/mediapipe/solutions/objectron.html#resources>.
11. <https://www.intelrealsense.com/depth-camera-d455/>

Thank
You