

CENTER FOR BIOTECH DATA SCIENCE

3-D Deep Learning-based Item Classification for Belt Conveyors Targeting Packaging and Logistics

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FAST ITEM SIZE MEASUREMENT SYSTEM FOR BELT CONVEYORS

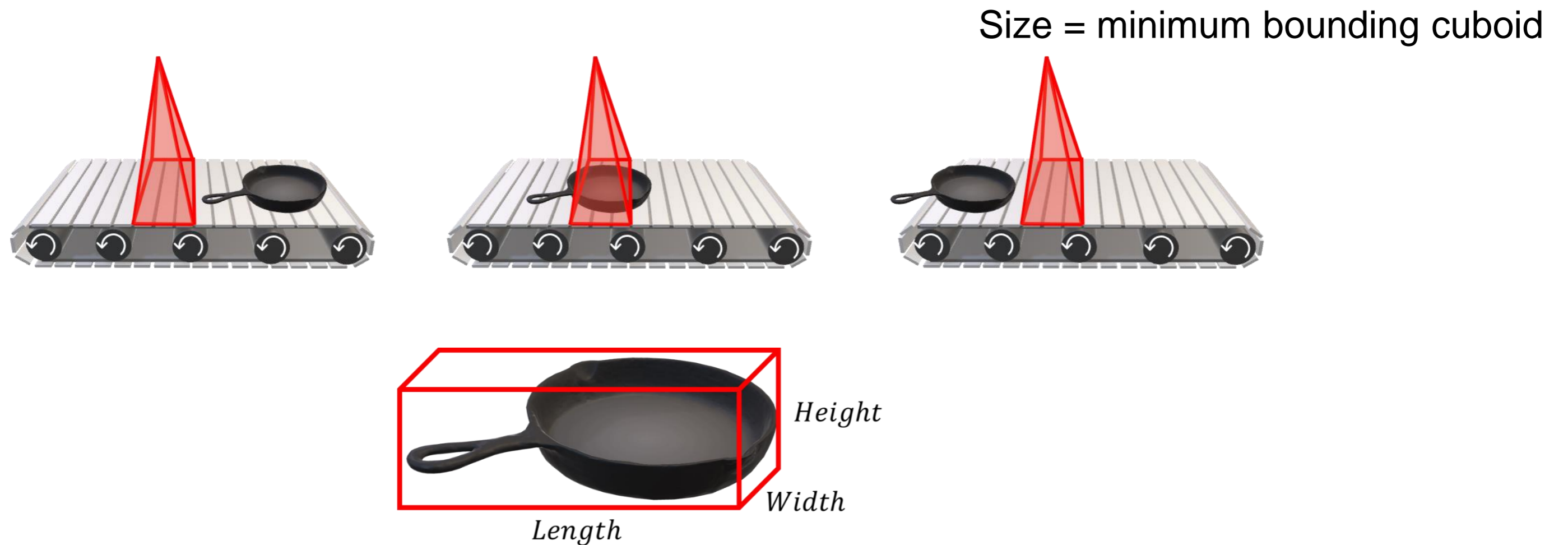


INTRODUCTION – PREVIOUS WORK

- **Background**
 - success of online shopping and e-commerce technology
 - need for quick and safe packaging of various types of items
 - requires accurate measurement of items at a high speed
- **What we present**
 - novel approach for item size measurement
 - targeting automated systems equipped with belt conveyors
 - leveraging a
 - scenario-driven approach
 - automata-based control design

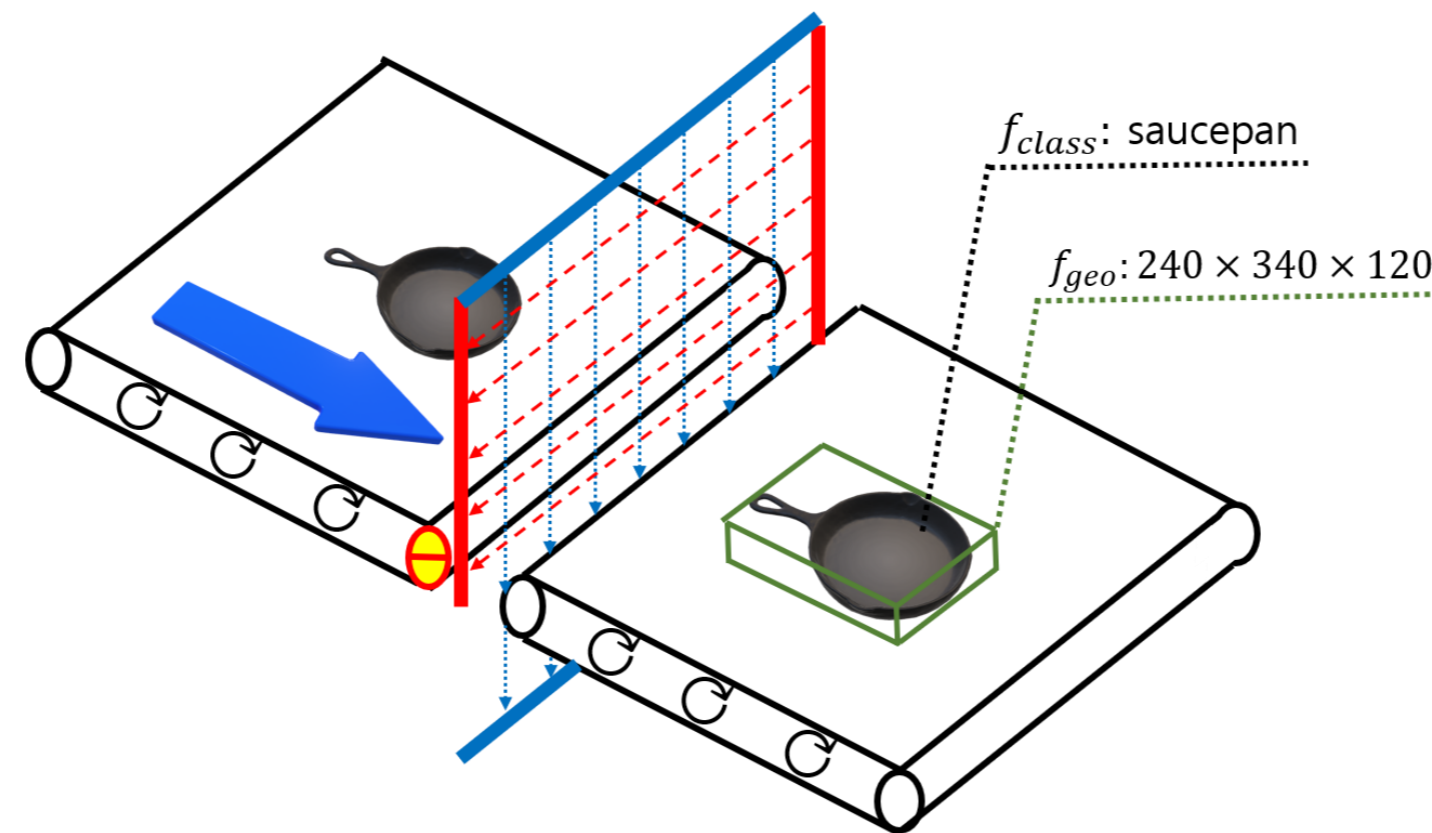
SCENARIO

- **Targeted system**
 - a packaging system using a belt conveyor
- **Measurement system**
 - input: sensor signals | output: item size



FUTURE WORK

- **3-D item reconstruction from sensor data**
- Robust size measurement in case of a tilted item insert
- **Item type classification from 3-D reconstructed data**
- Integrated system with a visualization component



FAST ITEM SIZE MEASUREMENT SYSTEM FOR BELT CONVEYORS



FAST ITEM CLASSIFICATION SYSTEM FOR BELT CONVEYORS

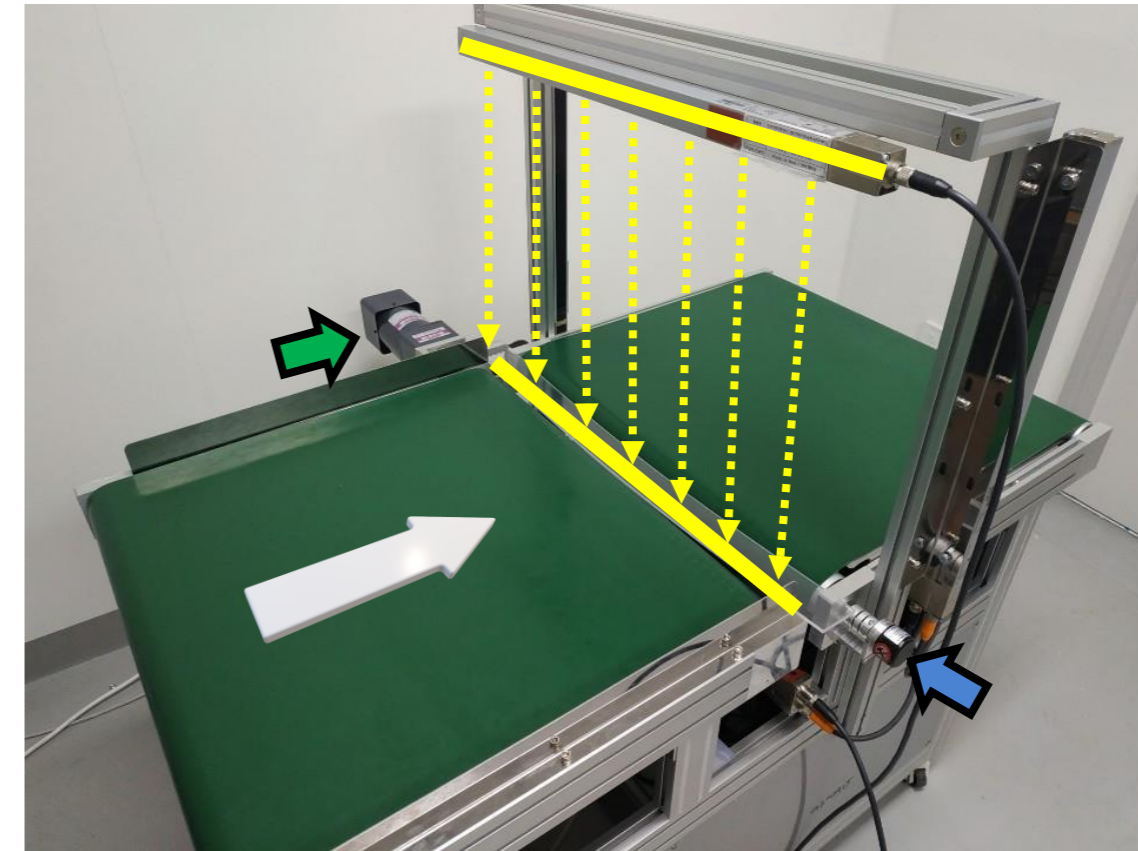


Type: frying pan

PROTOTYPE SETTINGS

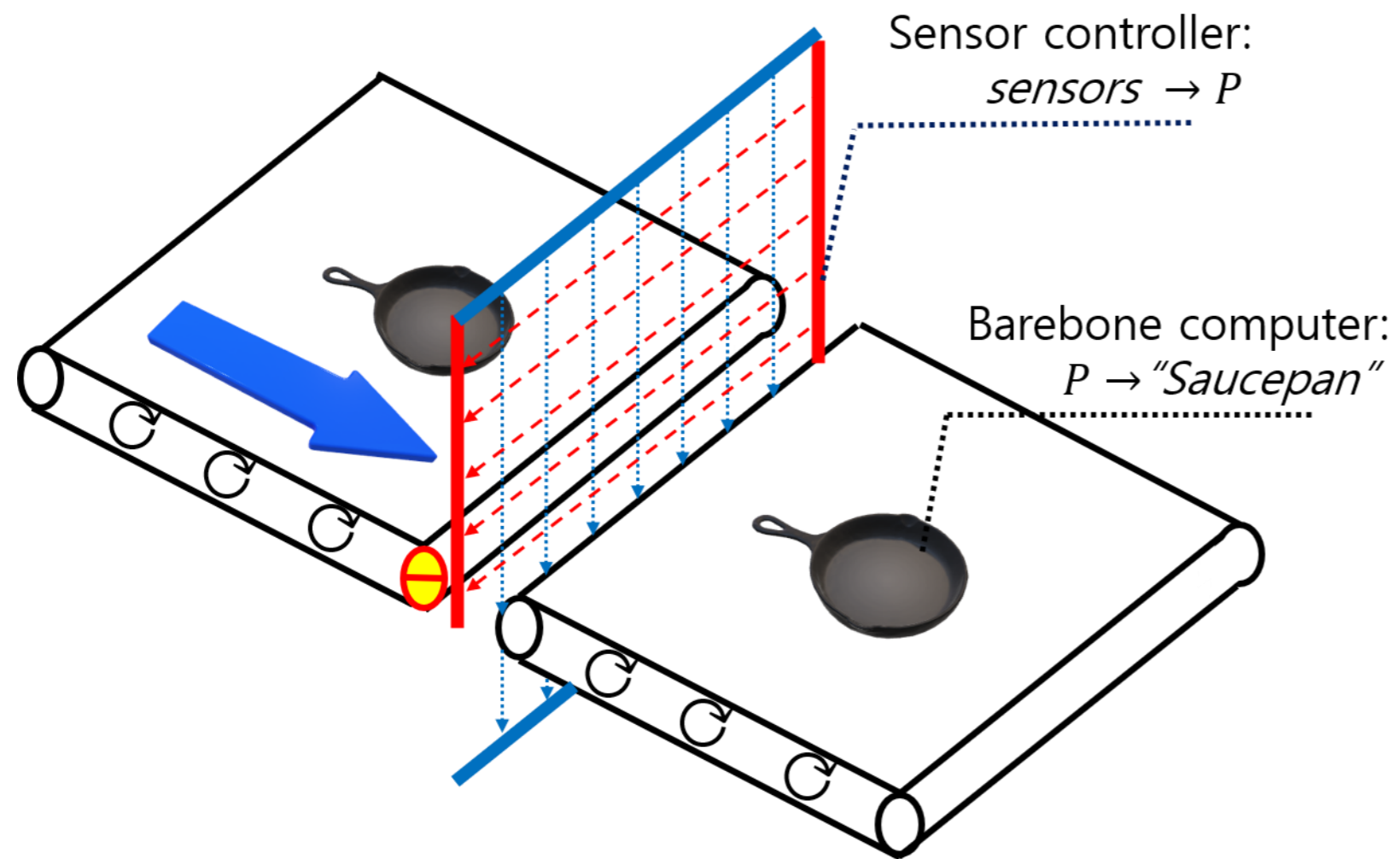


- White: item direction
- Green: motor
- Red: laser curtain sensor - height



- Yellow: laser curtain sensor - width
- Blue: rotary encoder

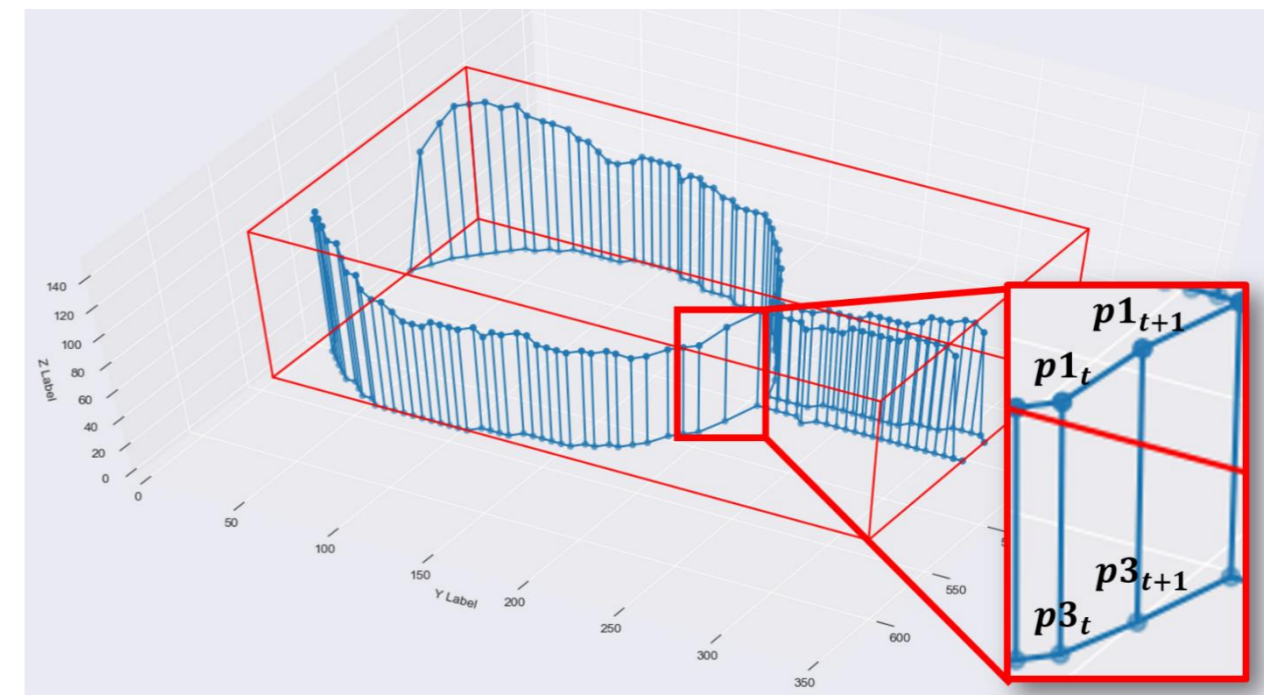
CONCEPT OVERVIEW



Hierarchical structure

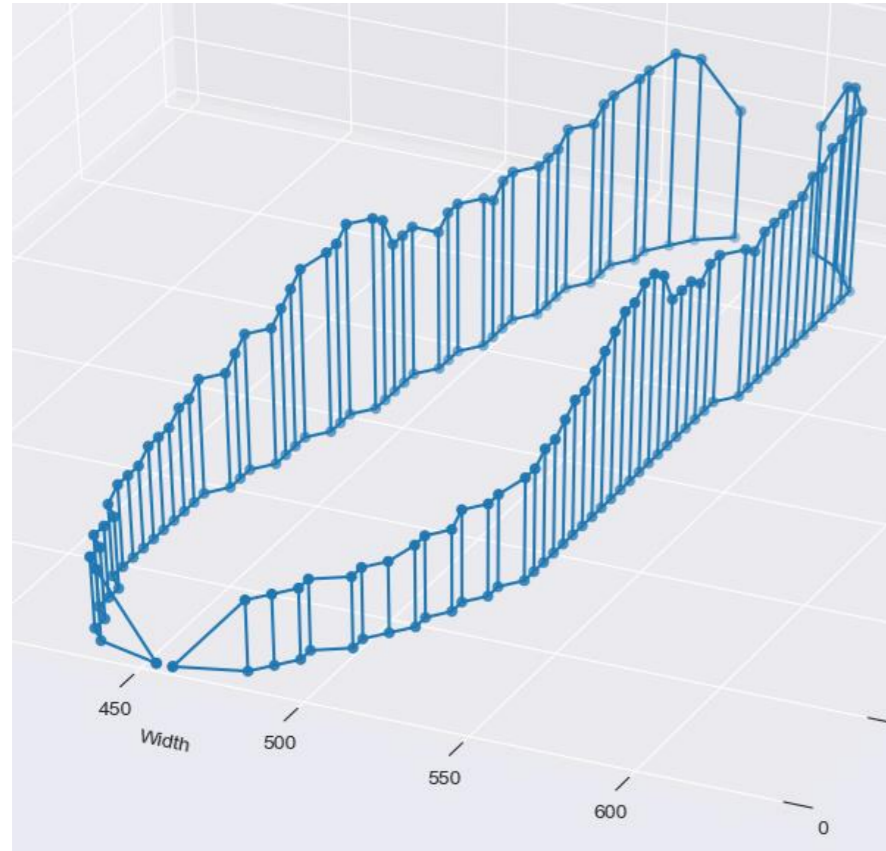
Time slot (ms)	FIB	LIB	Height	Length
10	200	380	210	4.97
20	205	385	210	9.81
30	205	385	210	14.4
...

Raw sensor data



3-D reconstruction

NEW METHOD – POINT CLOUD AUGMENTATION



Scanned dataset



Mesh generation



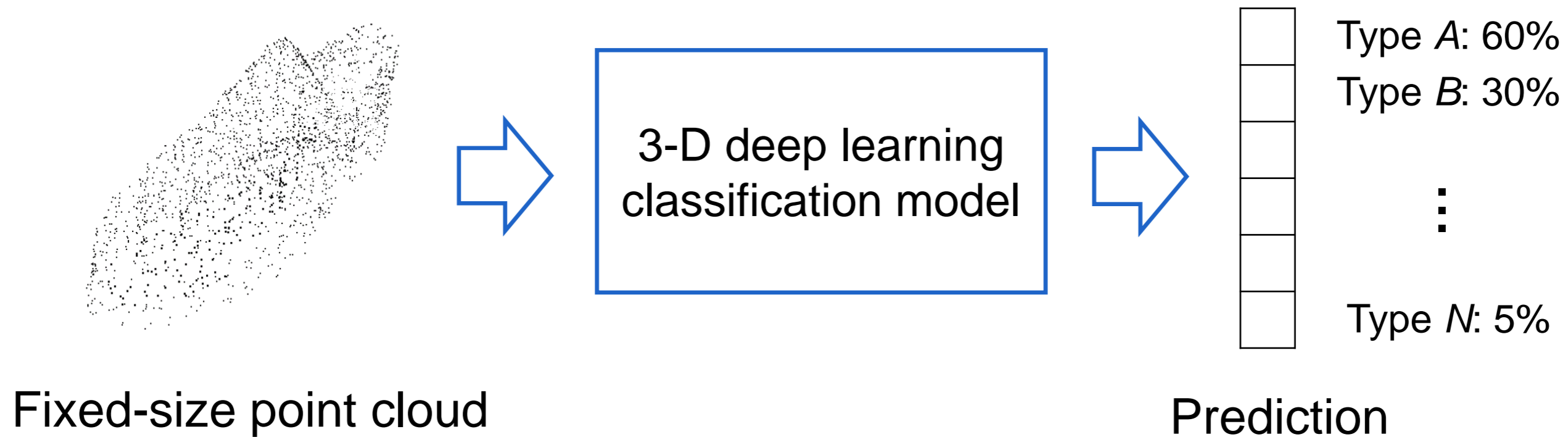
Point cloud augmentation

Variable-size point cloud
(depending on item length)



Fixed-size point cloud

ITEM TYPE CLASSIFICATION



ITEMS USED – 8 TYPES



Item in Fig. 2	Width	Height	Length
A (Box type 1)	259.54	105.92	349.00
B (Box type 2)	257.48	213.58	347.00
C (Box type 3)	320.00	284.93	422.00
D (Red book)	162.01	46.22	239.10
E (Blue book)	209.23	48.12	237.08
F (Saucepan)	185.48	92.49	317.00
G (Bucket)	190.06	162.00	191.03
H (Slipper)	105.85	85.78	289.57

EXPERIMENTAL SETUP

- **Dataset**

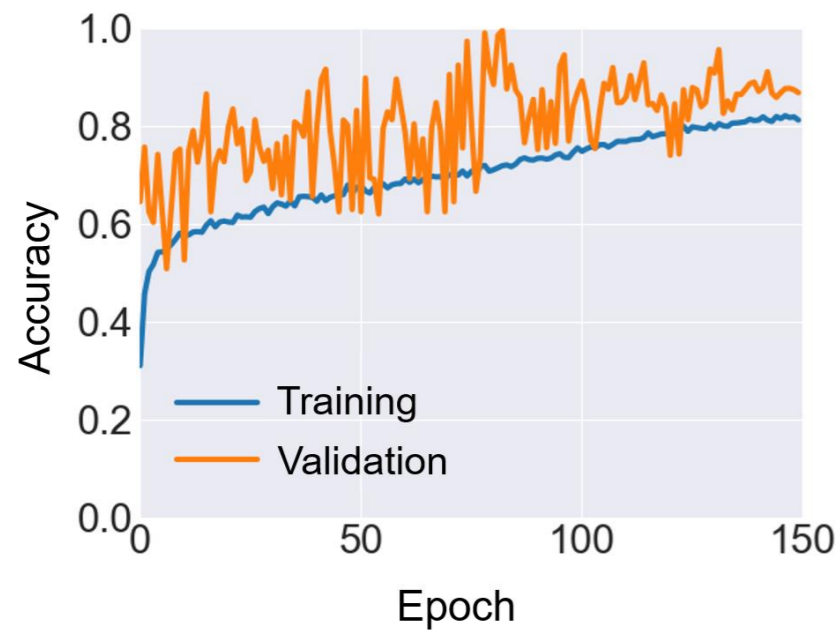
- scans of 8 different types of items
- Preprocessing & augmentation
 - centroid adjustment
 - random rotation (Z-axis fixed)
- 14,400 point clouds

- **Experiments**

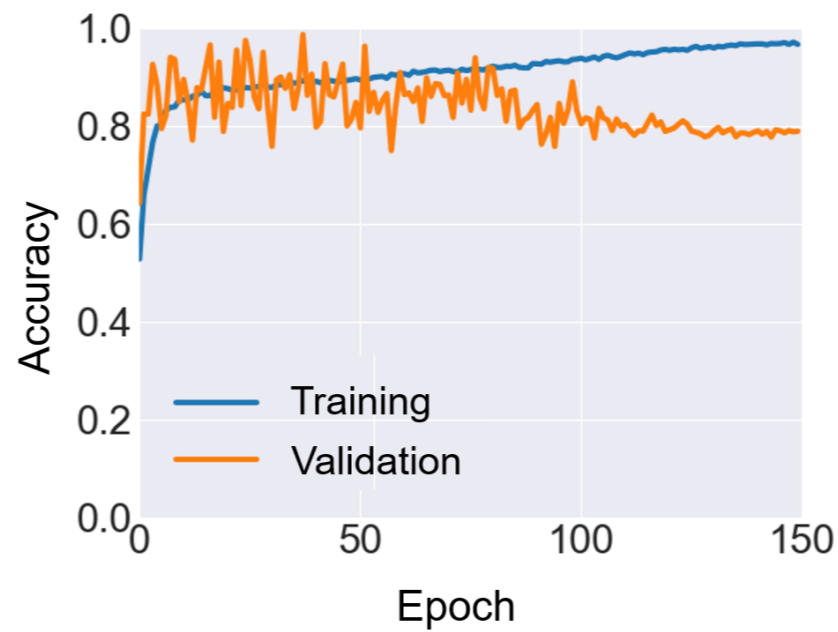
- 3 candidate models: PointNet, PointNet++, and DGCCNN
- data: 80% for training | 20% for testing

EXPERIMENTAL RESULTS

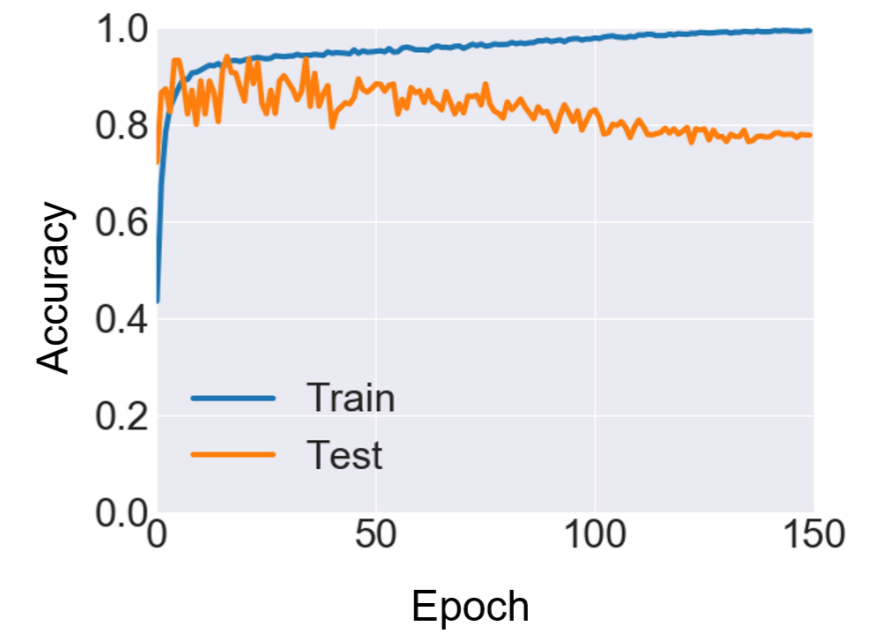
	Final training accuracy	Final validation accuracy	Model size (Mb)	Response time (ms)
PointNet	0.81	0.87 (0.79)	1.10	0.025 (± 0.015)
PointNet++	0.97	0.79 (0.84)	5.77	0.453 (± 0.001)
DGCNN	0.99	0.78 (0.83)	7.06	0.027 (± 0.000)



PointNet



PointNet++



DGCNN

DISCUSSION AND CONCLUSIONS

- **Summary**

- fast item classification for belt conveyor systems
- 3-D reconstruction by combining different sensors
- new method to obtain a fixed-size point cloud
- training and testing of a 3-D classification model

- **Future work**

- integrated measurement and classification system
- construction of a system that is more industrially applicable
 - multi-modal approach: 3-D + regular camera + barcode + ...

Thank you for your attention! Any questions?

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