Machine Learning and Computer Vision Techniques for Optimizing the Manufacturing Process of Porcelain

KNOWLEDGE TRANSFER TO AN ECONOMIC AGENT PROJECTS

- *Intelligent system based on machine learning and computer vision for the optimization of the manufacturing process of porcelain (SIVAP). UEFISCDI.*
- *Computational Models for Reproducing Ceramics Colors (CMRCC). UEFISCDI.*

Machine Learning and Computer Vision Techniques for the Optimization of the Manufacturing Process of Porcelain

- Motivation
- Problems Description
- Solutions
- Results
- Summary & Conclusions

Motivation – Alba Iulia – porcelain industry

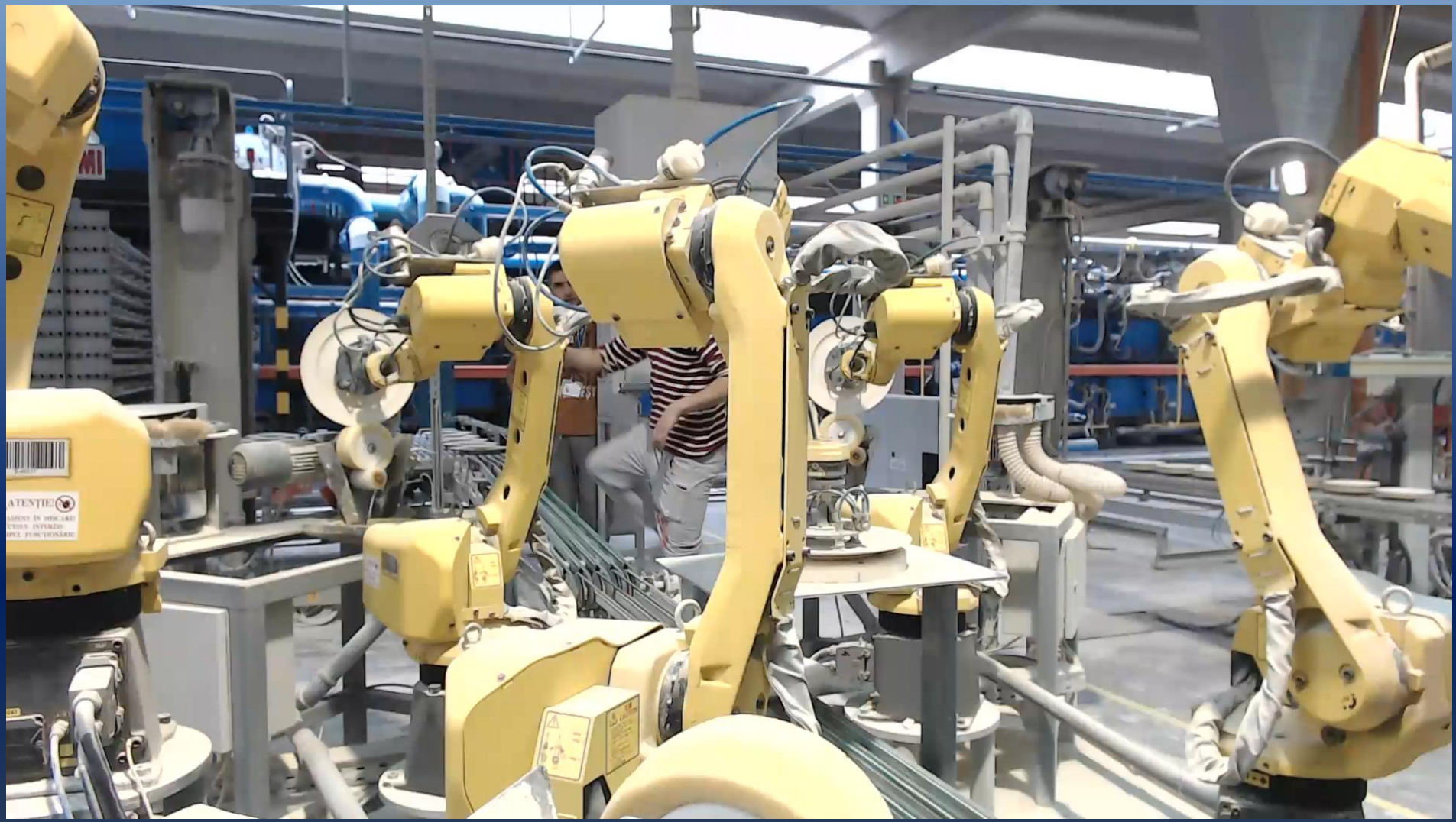
Motivation

Manufacturing Process of Porcelain

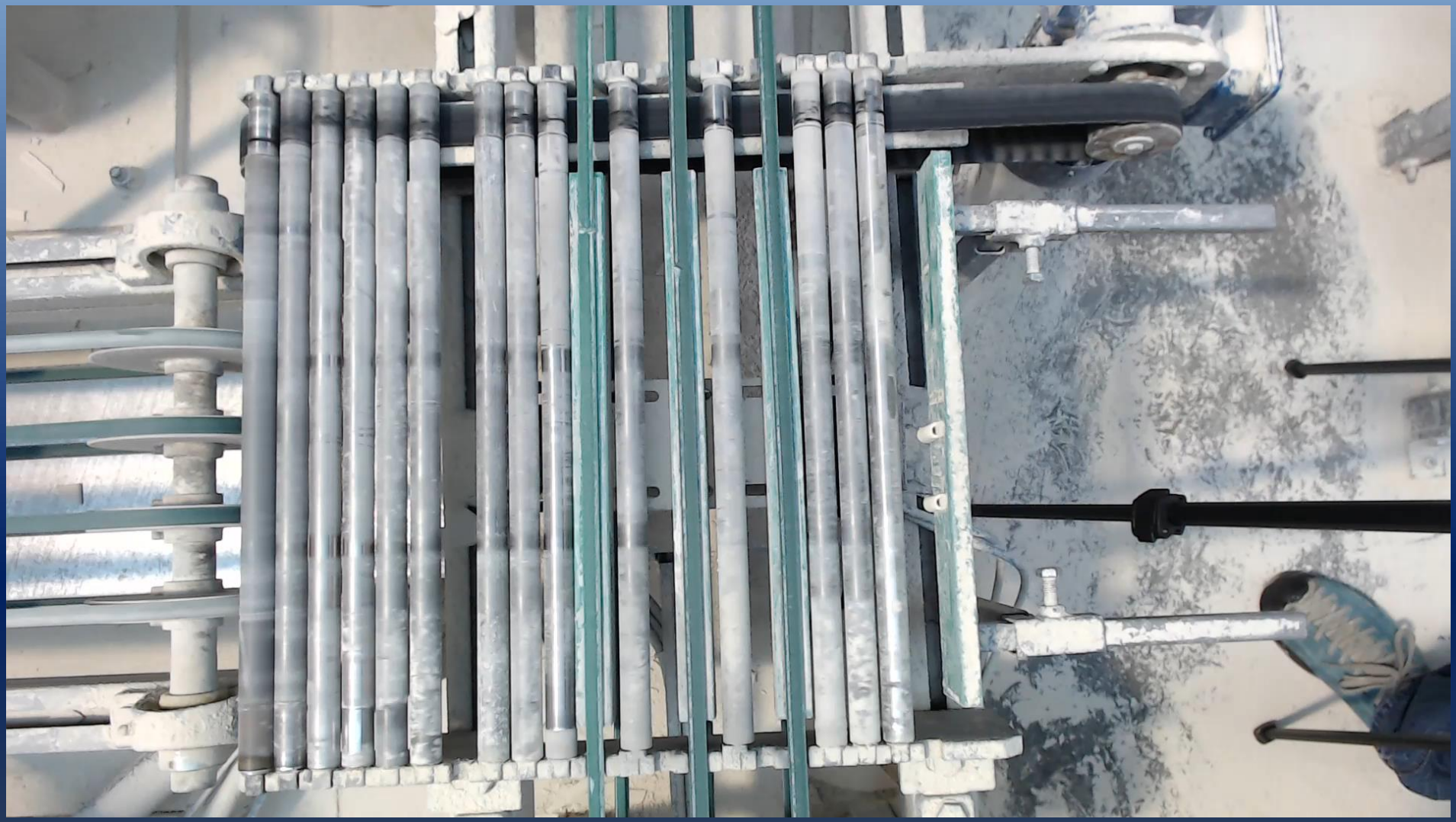
- Preparing the mass
- Powder atomization
- Shaping the object
- Burning 1
- Glazing
- Burning 2
- Quality control
- Sorting

Motivation

Motivation



Motivation



Motivation

Quality control after:

1) Burning 1

2) Glazing

3) Sorting

Estimated cost reduction

- 60% in HR

- 20% in materials

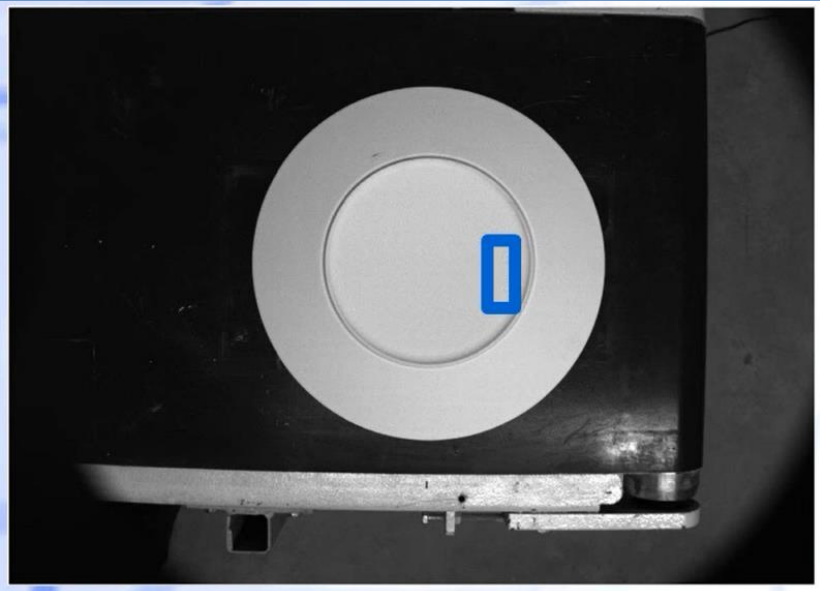
Challenges

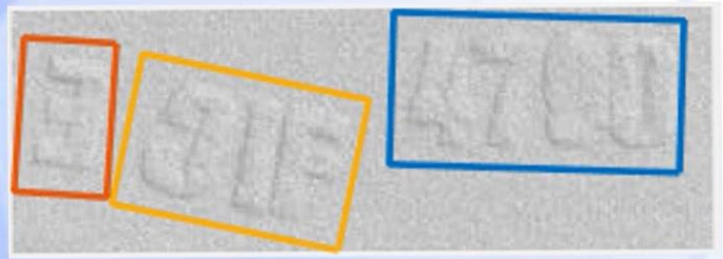
I. Automatic character recognition in porcelain ware

II. Defect identification

III. Automatic Design and Correction of Ceramic Colours

Automatic character recognition in porcelain ware
Problem description





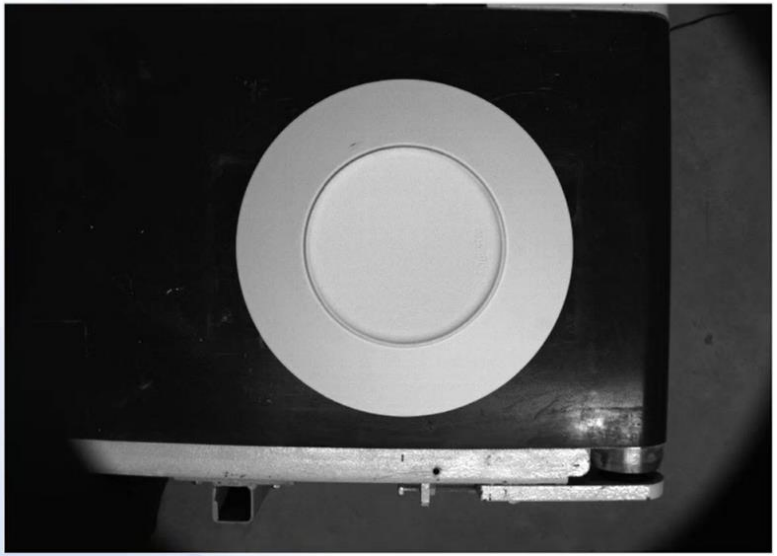
3 groups of characters:
- Sack of material
- Work shift
- Product type

Solution { **SEGMENTATION + IDENTIFICATION**

Automatic character recognition in porcelain ware
Segmentation process

- **Objective:** segment individual characters.

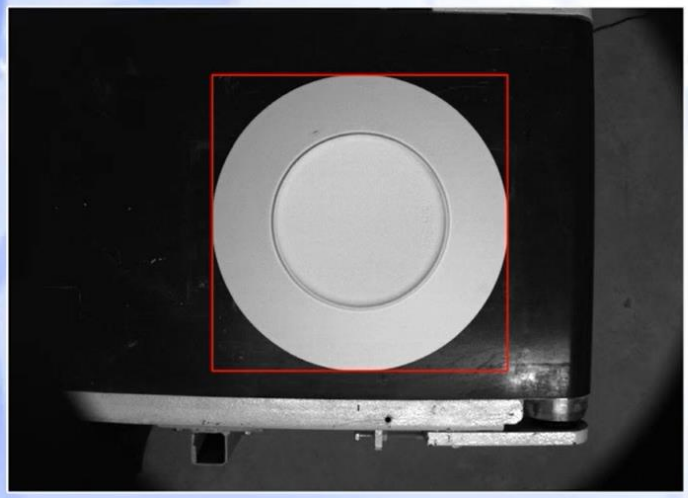
- **Solution:** recursively look for geometric properties and segment.

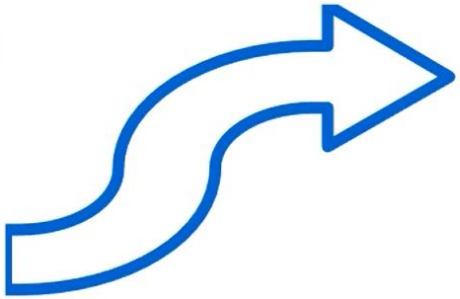


Automatic character recognition in porcelain ware
Segmentation process

- **Solution:** binarize image, study 8-connected components in contiguous regions.

❖ **Outer Bounding Box of largest object**

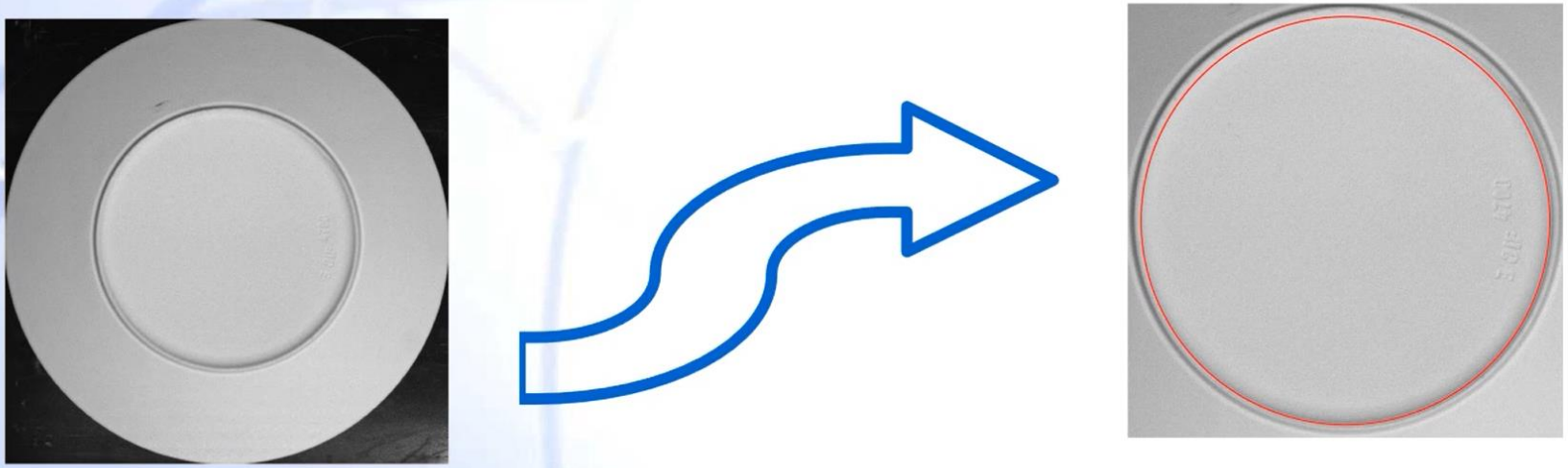




Automatic character recognition in porcelain ware
Segmentation process

- **Solution:** study geometric properties and segment.

❖ Segment inner circle

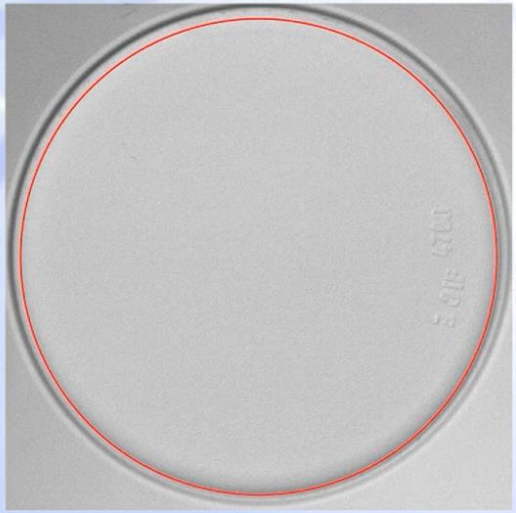


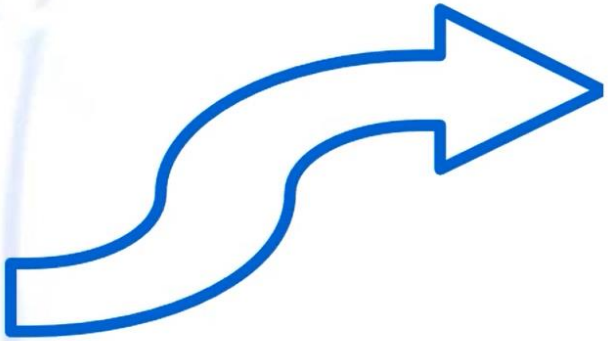
$$circularity = perimeter / 4 * \pi * area$$

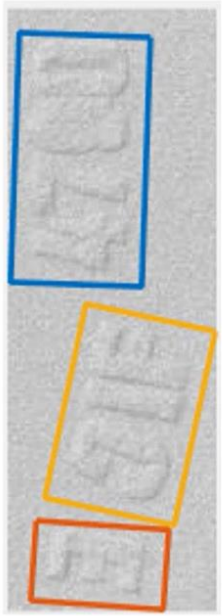
Automatic character recognition in porcelain ware
Segmentation process

- **Solution:** binarized image, study 8-connected components in contiguous regions.

❖ **Perform several binarizations until 3 boxes of the expected area are found.**

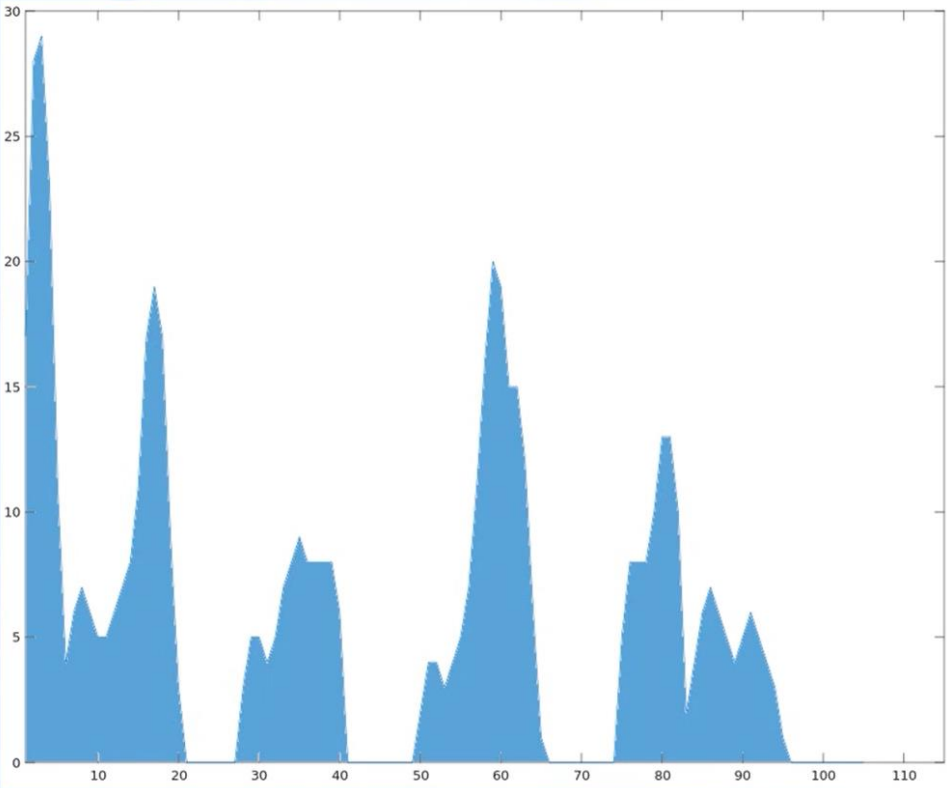


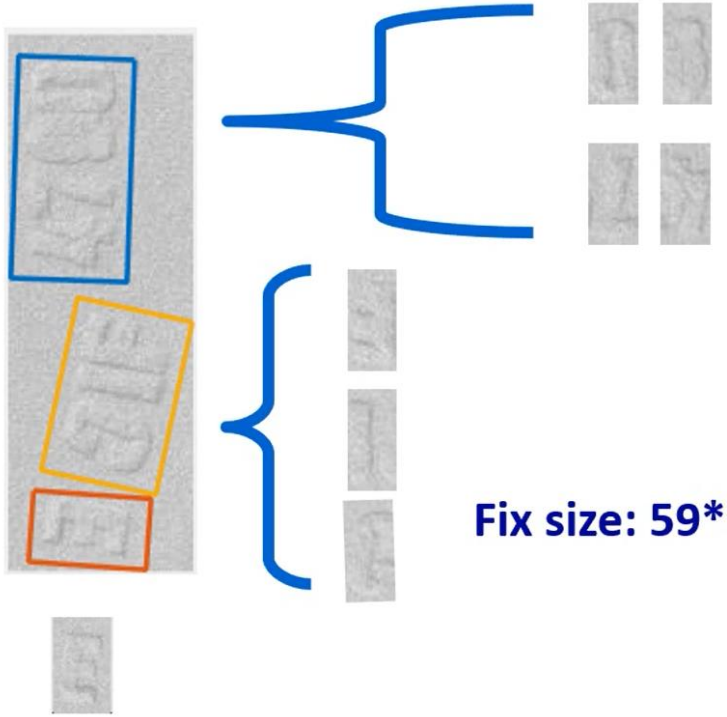




Automatic character recognition in porcelain ware
Segmentation process

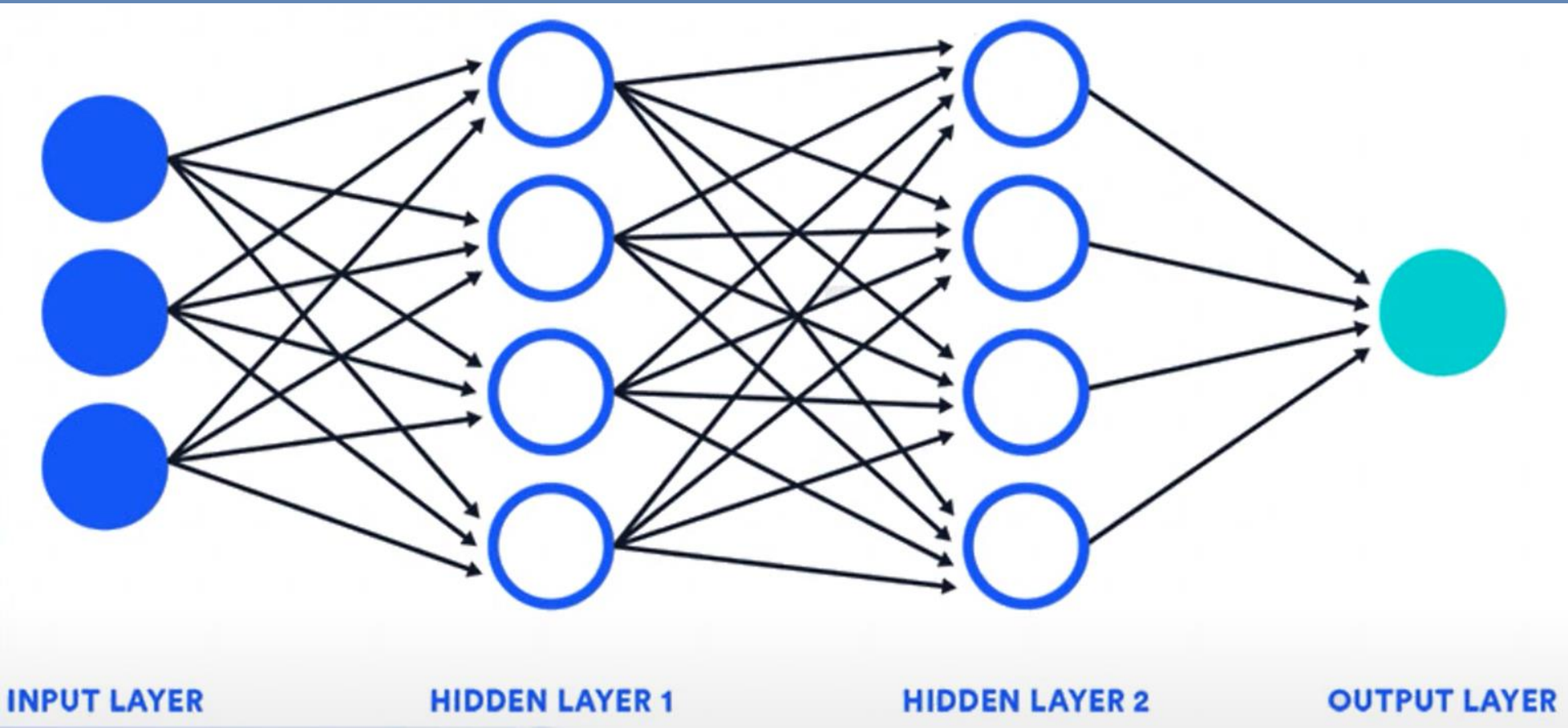
- **Solution:** binarize image and study X-projection



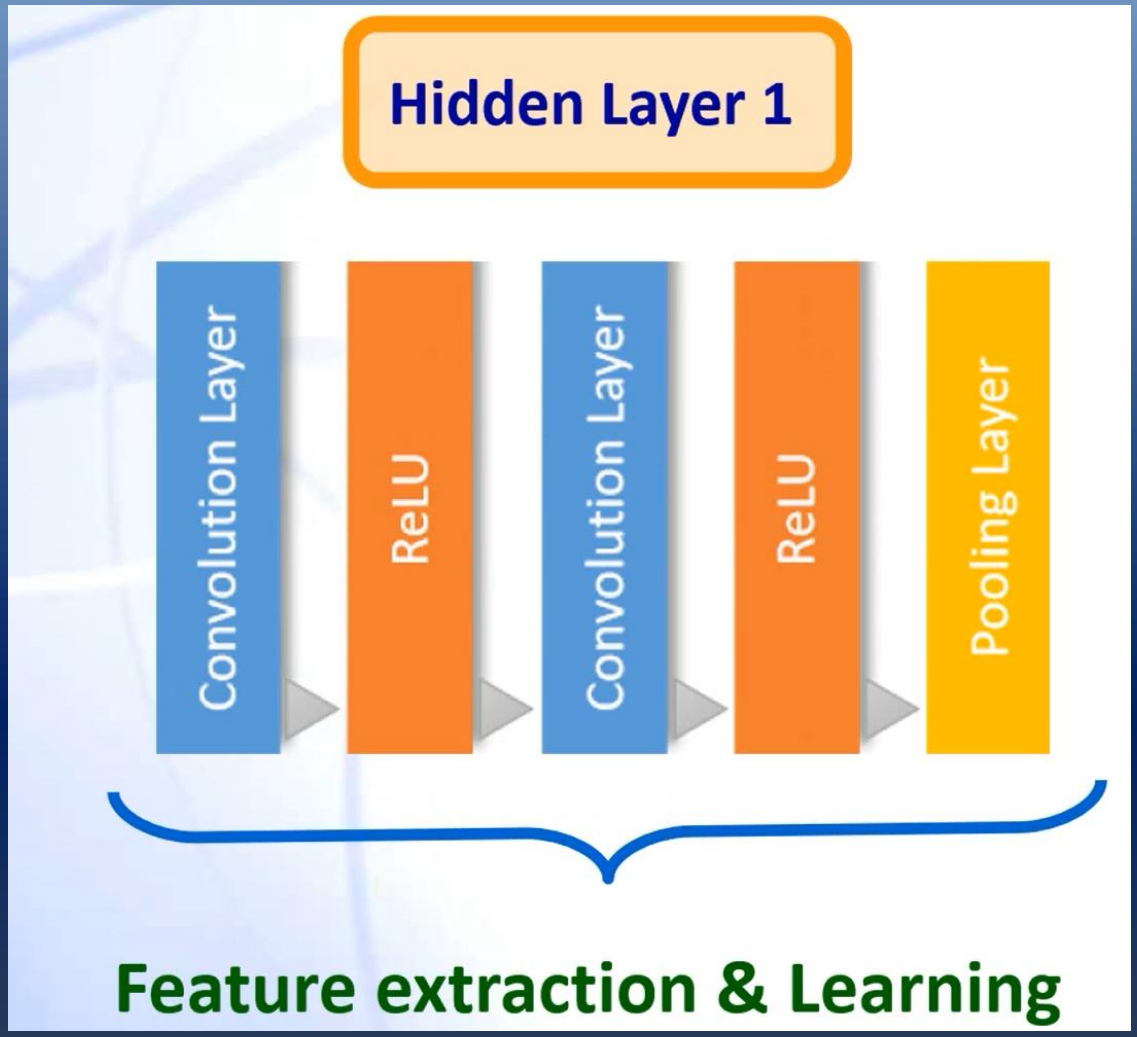


Fix size: 59*35º

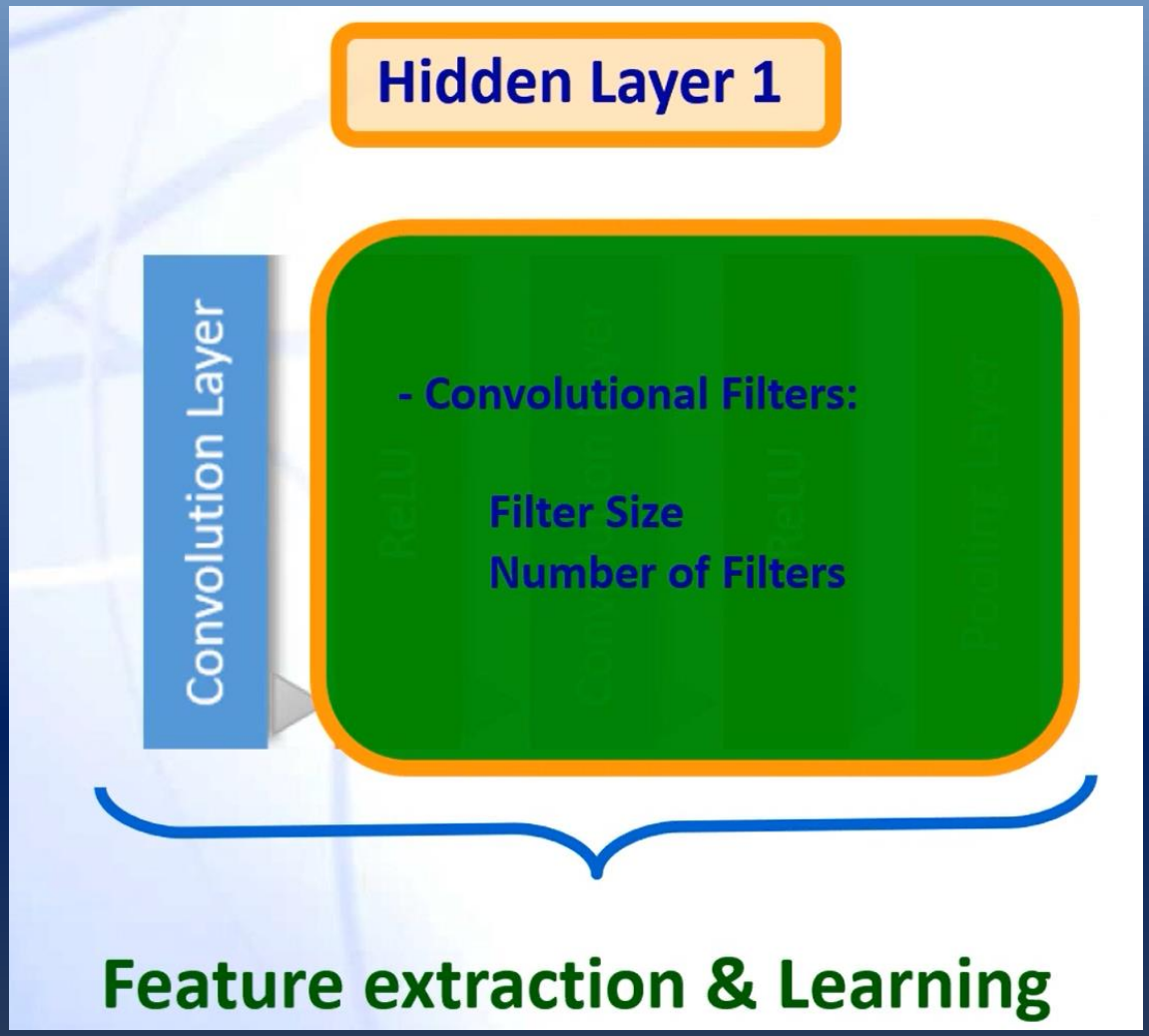
Convolutional neural networks for classification



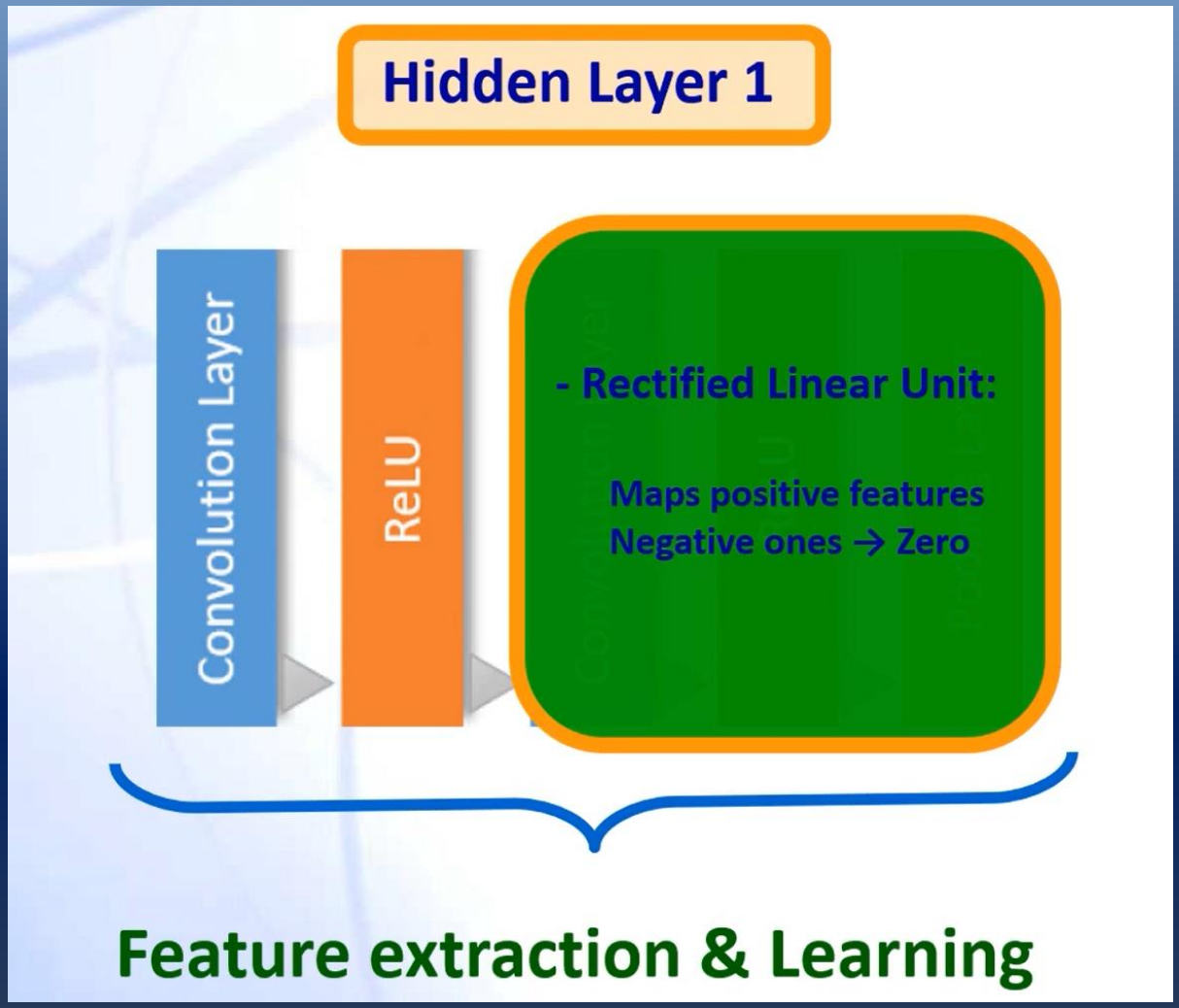
Automatic character recognition in porcelain ware



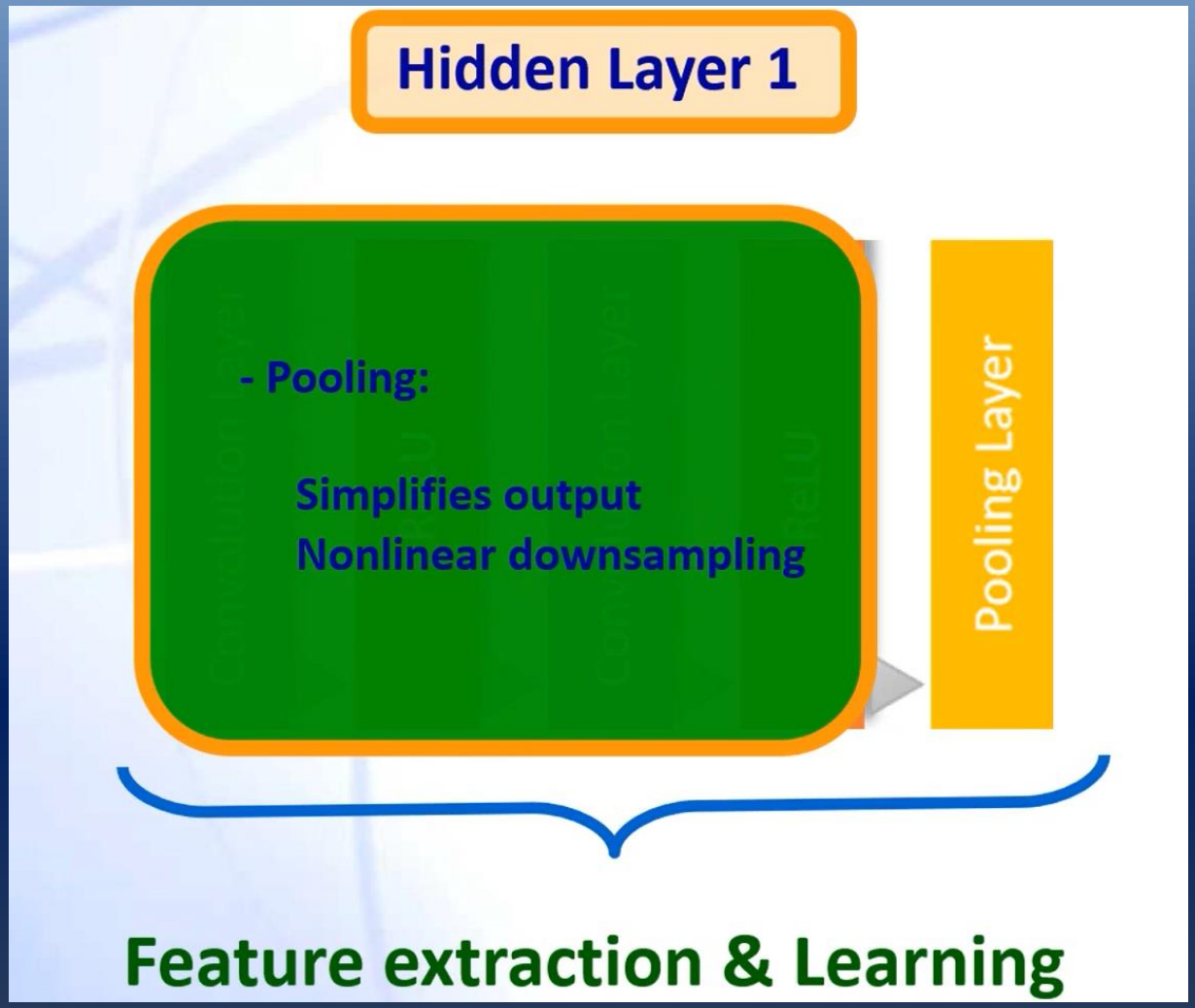
Automatic character recognition in porcelain ware



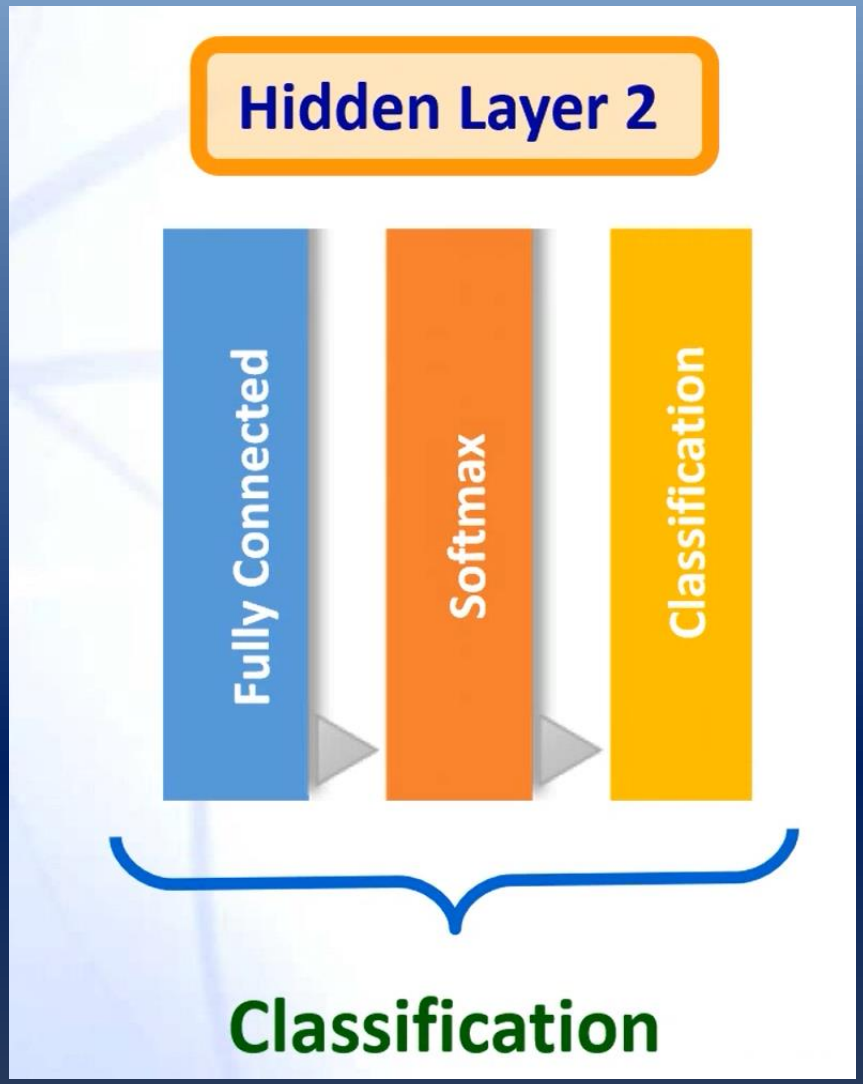
Automatic character recognition in porcelain ware



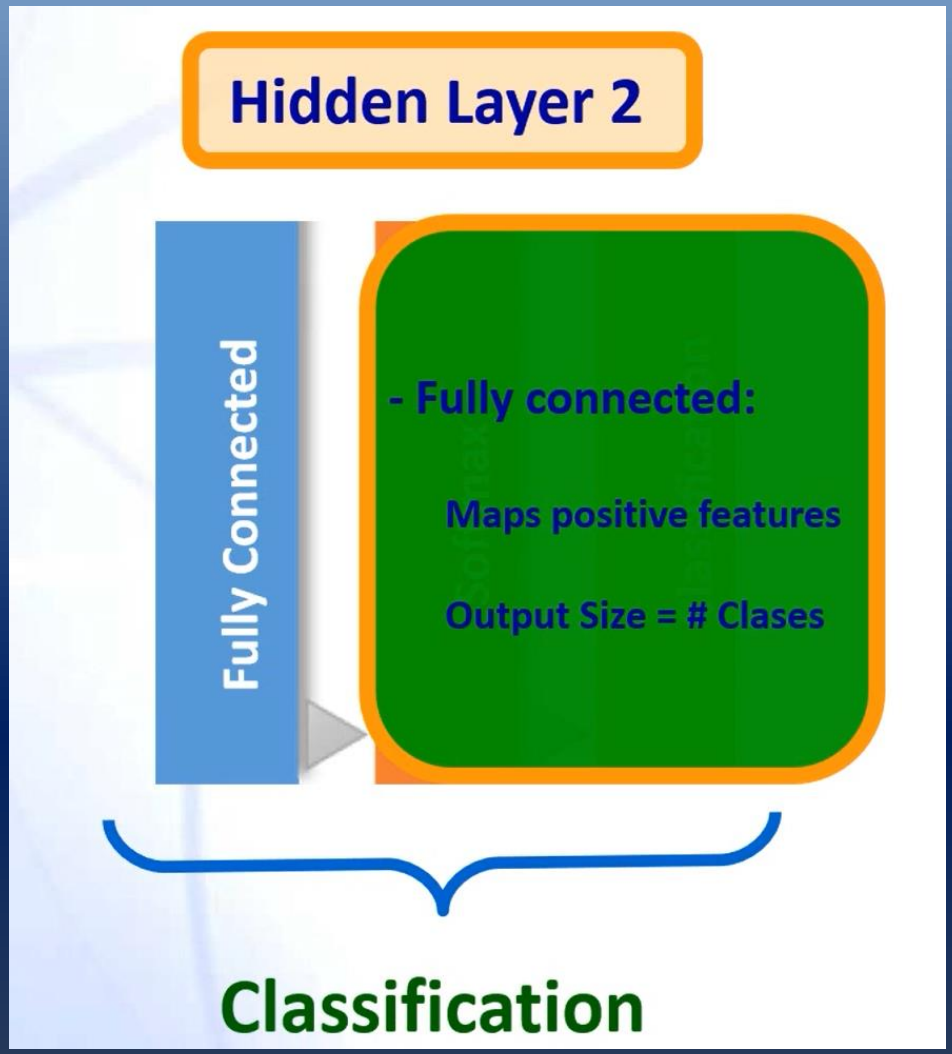
Automatic character recognition in porcelain ware



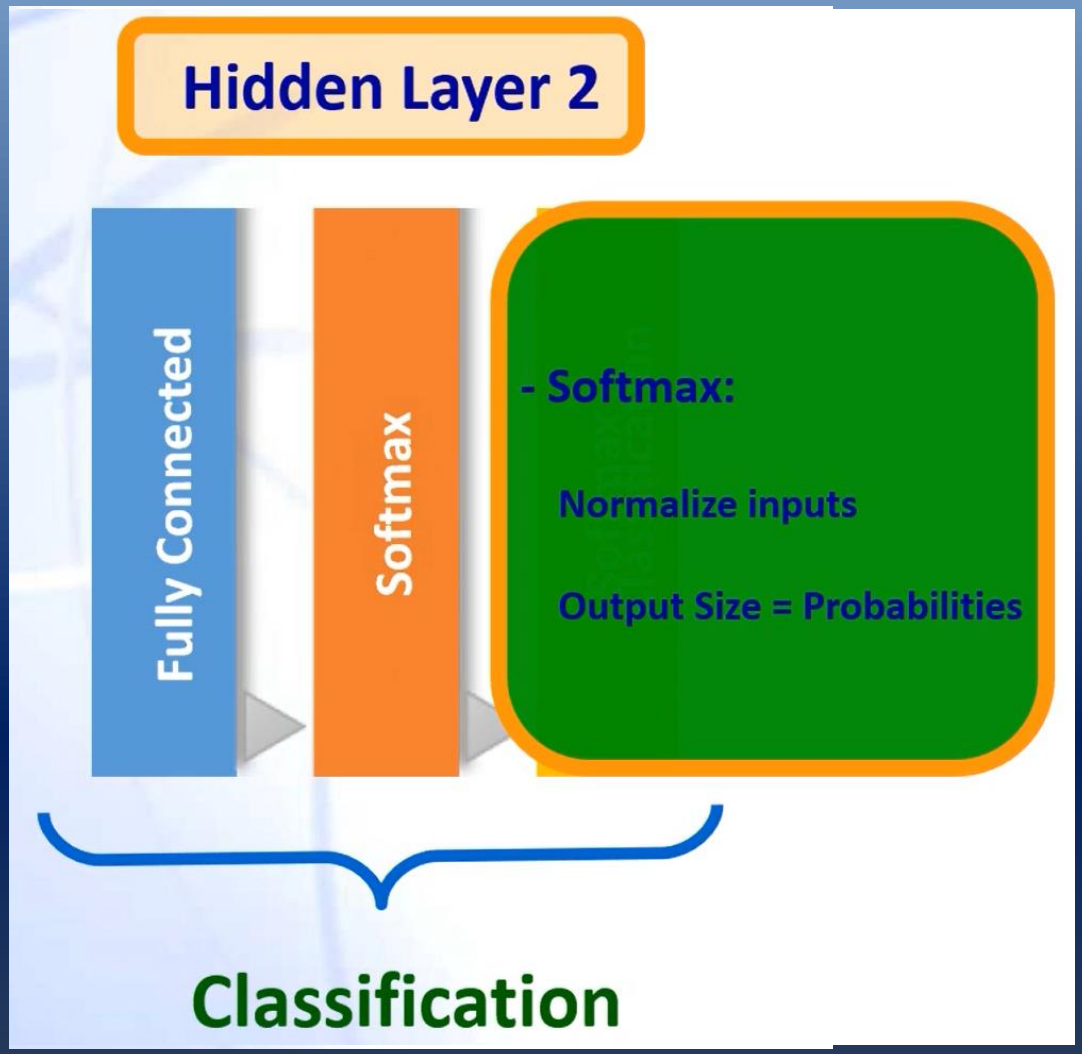
Automatic character recognition in porcelain ware



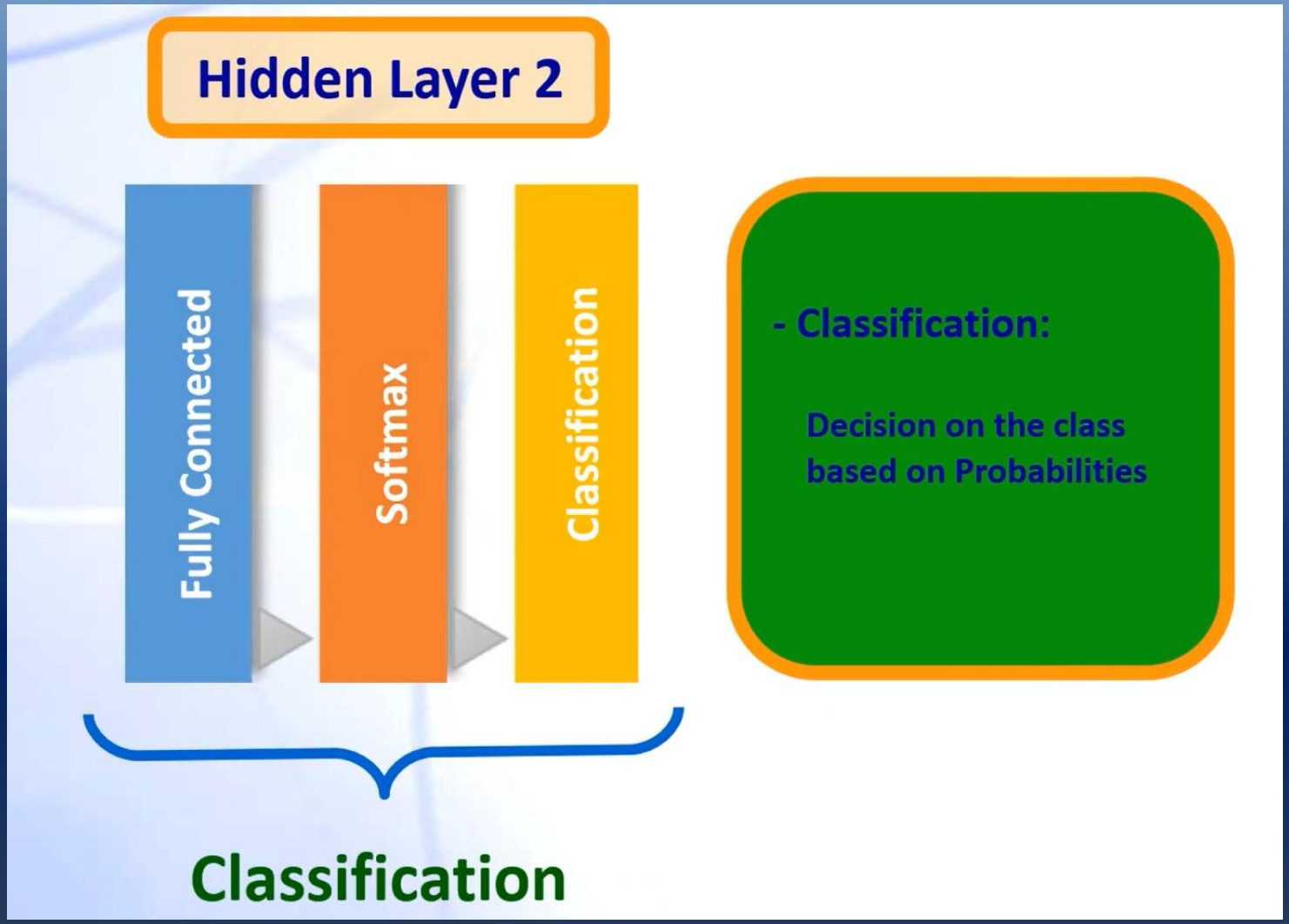
Automatic character recognition in porcelain ware



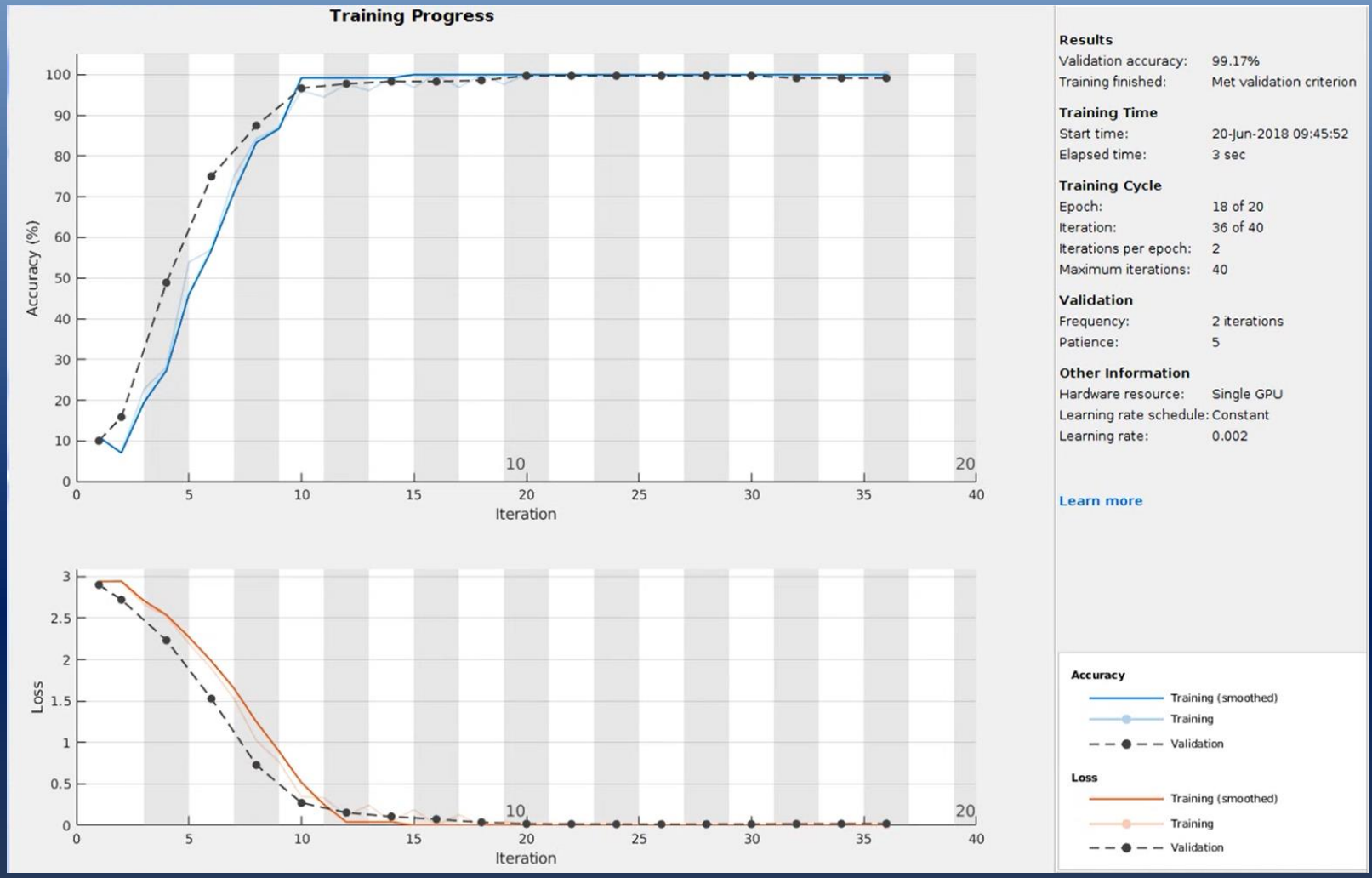
Automatic character recognition in porcelain ware



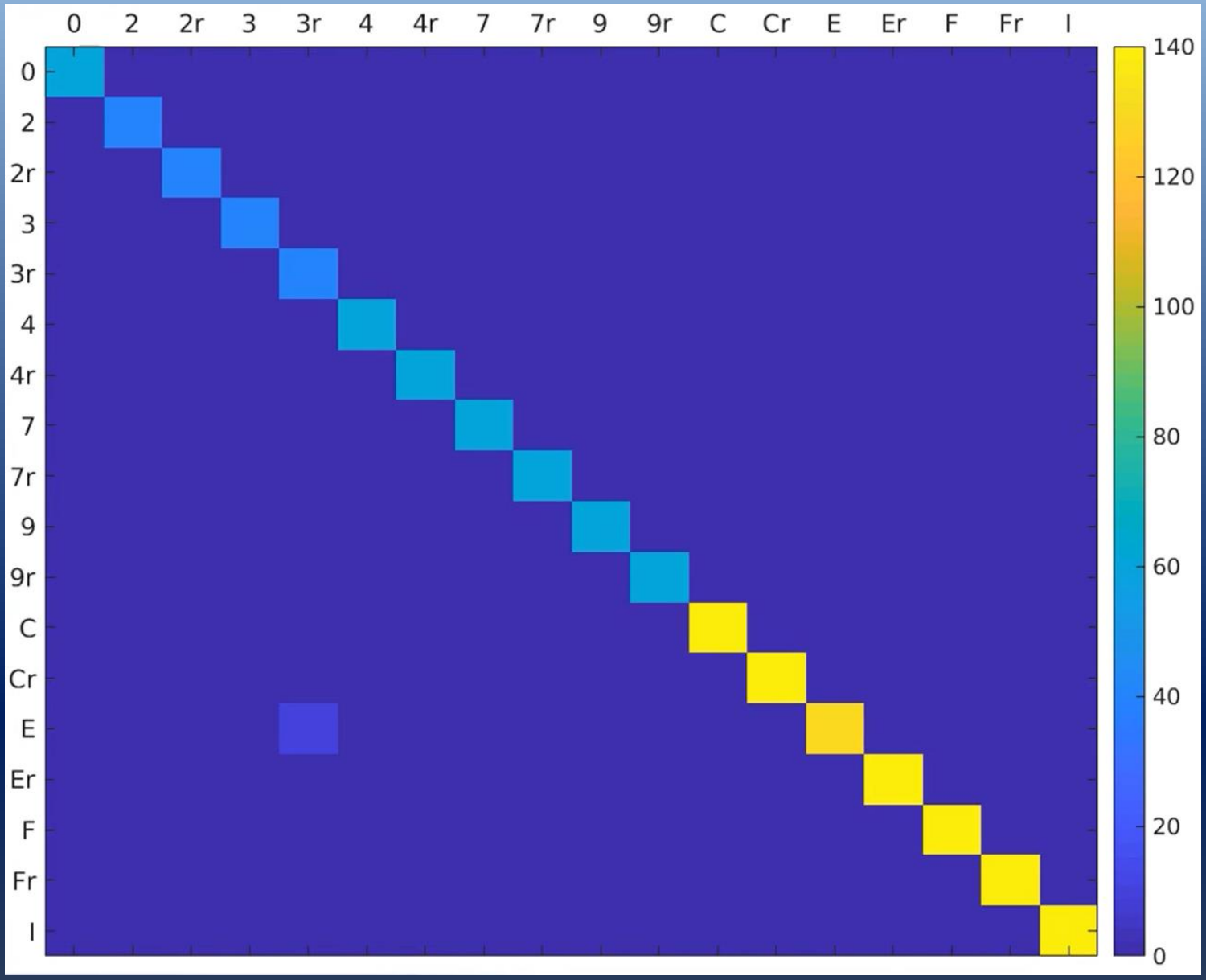
Automatic character recognition in porcelain ware



Results


Training Progress
Accuracy (%)
Iteration
Loss
Iteration
Results
Validation accuracy: 99.17%
Training finished: Met validation criterion
Training Time
Start time: 20-Jun-2018 09:45:52
Elapsed time: 3 sec
Training Cycle
Epoch: 18 of 20
Iteration: 36 of 40
Iterations per epoch: 2
Maximum iterations: 40
Validation
Frequency: 2 iterations
Patience: 5
Other Information
Hardware resource: Single GPU
Learning rate schedule: Constant
Learning rate: 0.002
Learn more
Accuracy
Training (smoothed)
Training
Validation
Loss
Training (smoothed)
Training
Validation

Results


0 2 2r 3 3r 4 4r 7 7r 9 9r C Cr E Er F Fr I
0 2 2r 3 3r 4 4r 7 7r 9 9r C Cr E Er F Fr I
140 120 100 80 60 40 20 0

Summary & Future work

✓ **Successful Character Recognition in round flat plates.**

- ❖ **Parameterize segmentation process for other types of ware.**
- ❖ **Add more characters to the database.**
- ❖ **Study possible corrections for bad detections.**

- Currently labelling a data set of approx. 10.000 images – make it available

Challenges

I. Automatic character recognition in porcelain ware

II. Defect identification

III. Automatic Design and Correction of Ceramic Colours

Defect identification
Types of defects

- 2D defects
- 3D defects
- structure defects

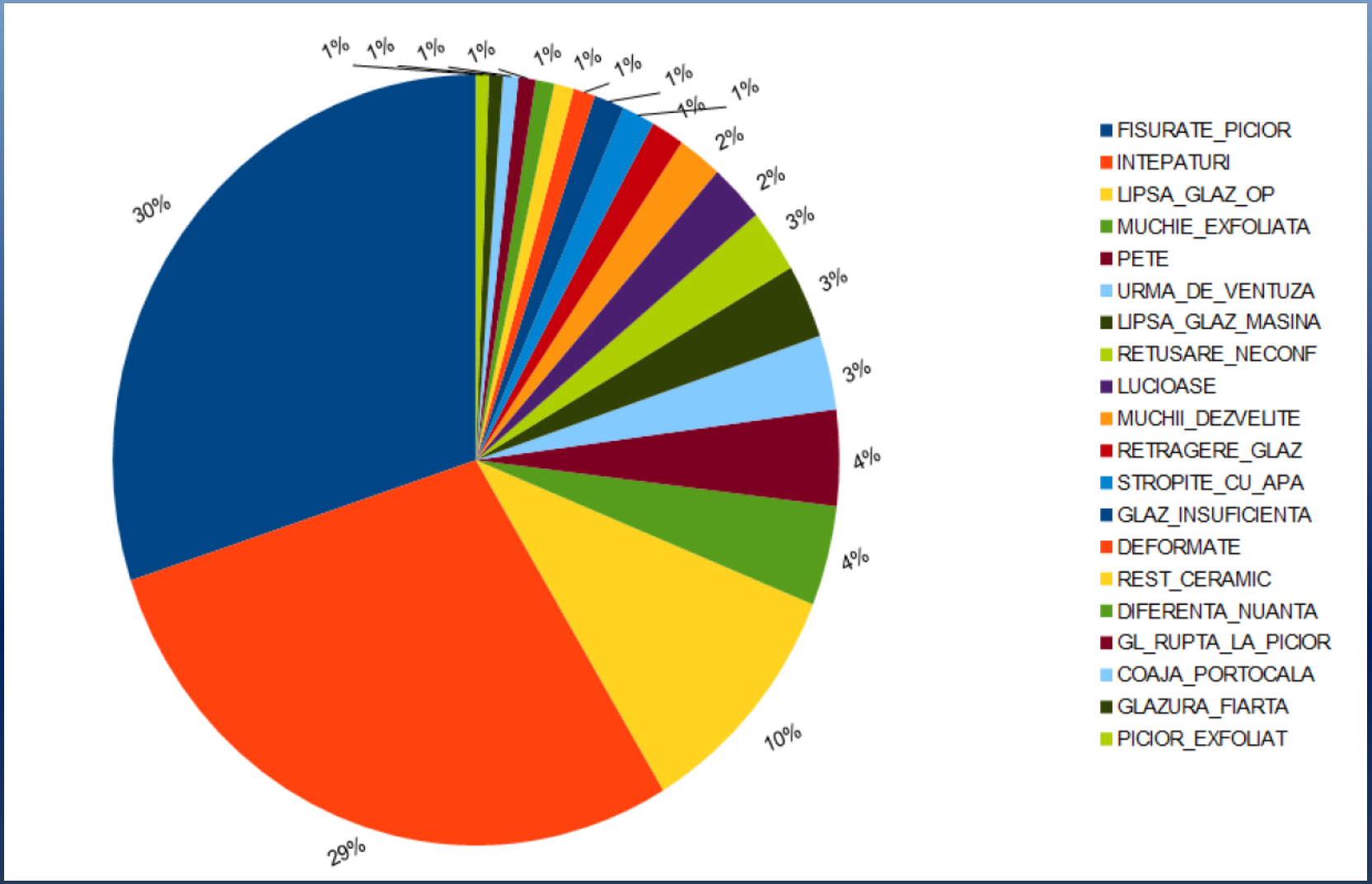
(a) Deterioration after pressing.

(d) Margin deformation.

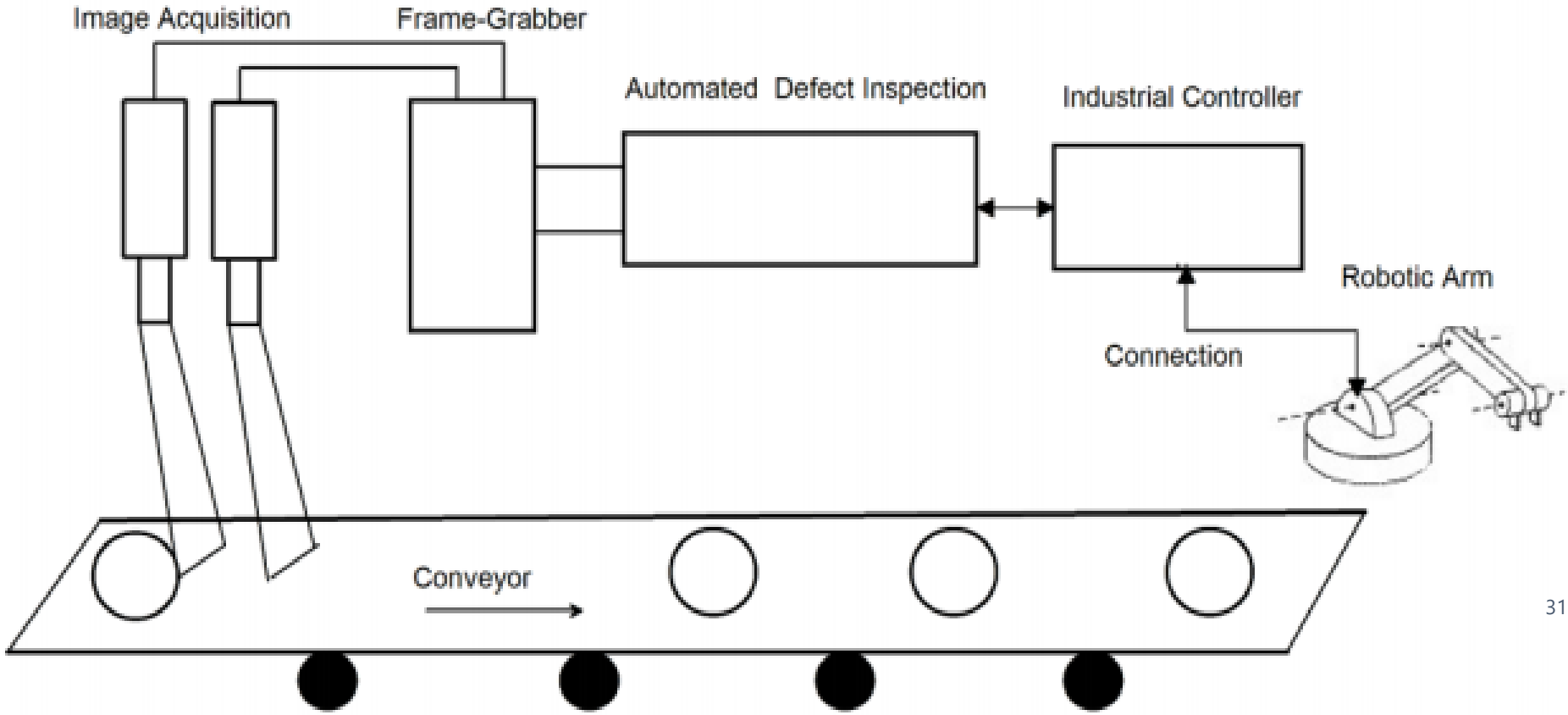
(b) Bumps.

(c) Texture defects.

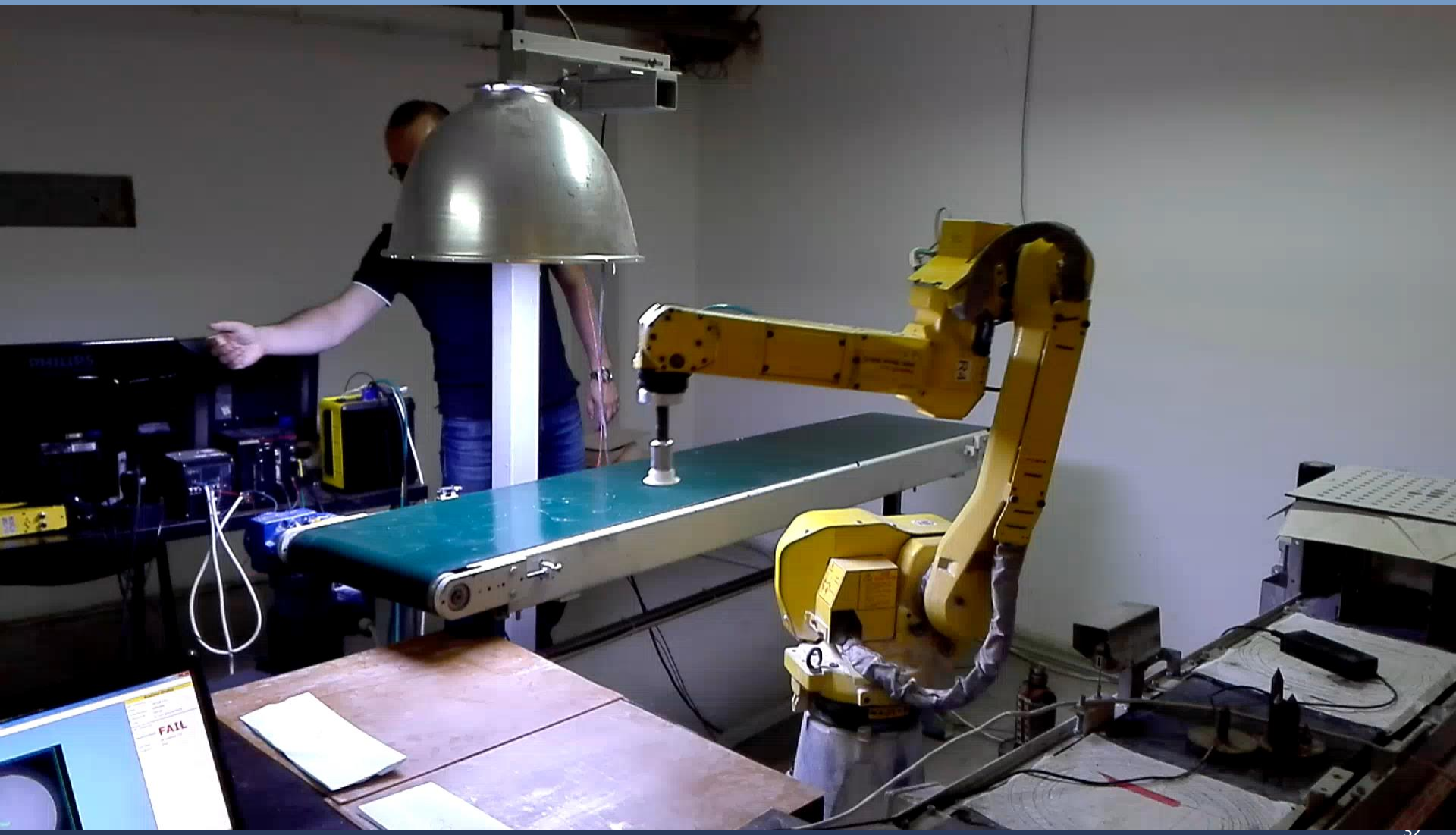
Defect identification
Types of defects



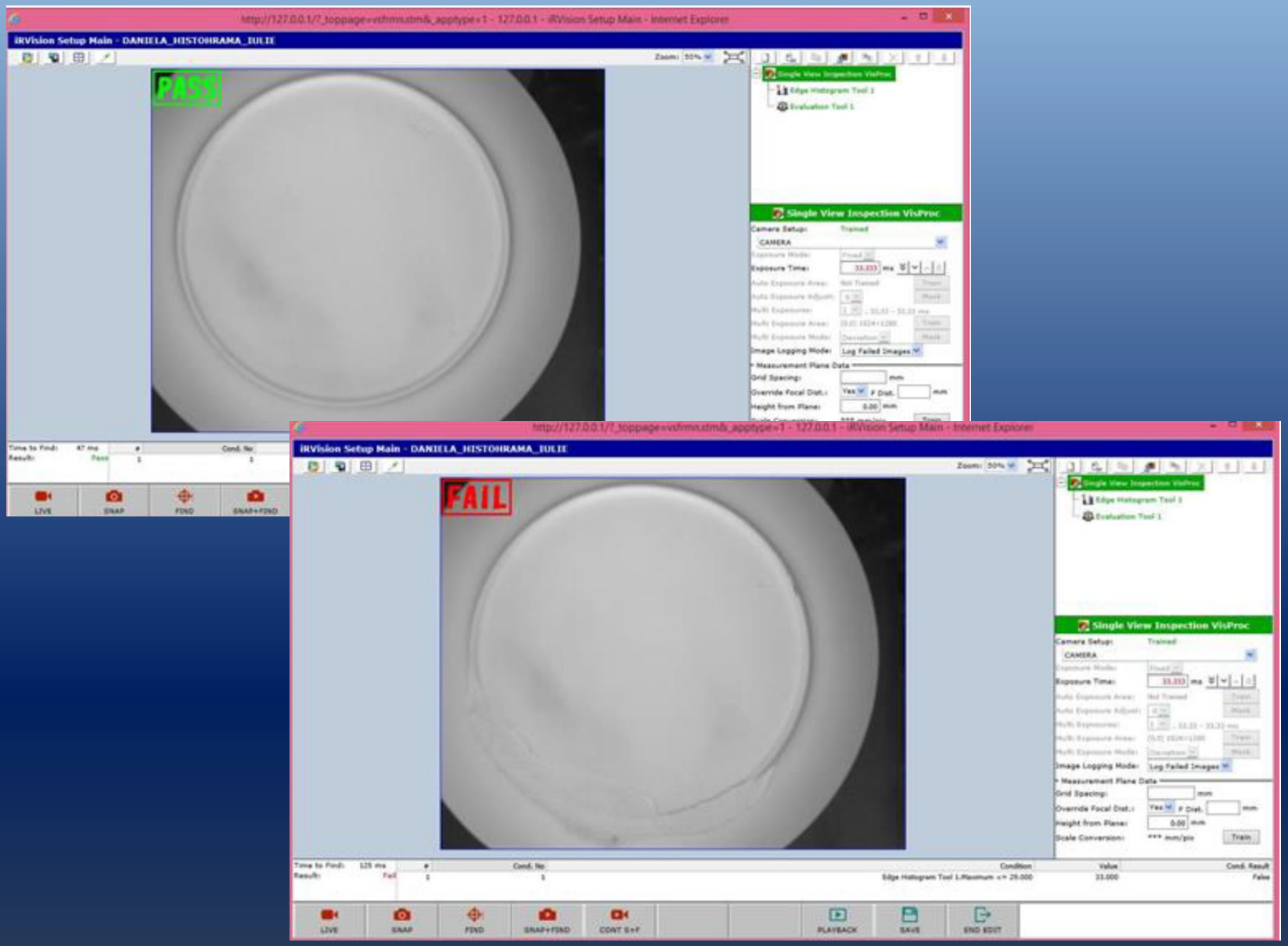
Automated processes in porcelain industry



Defect identification - demo



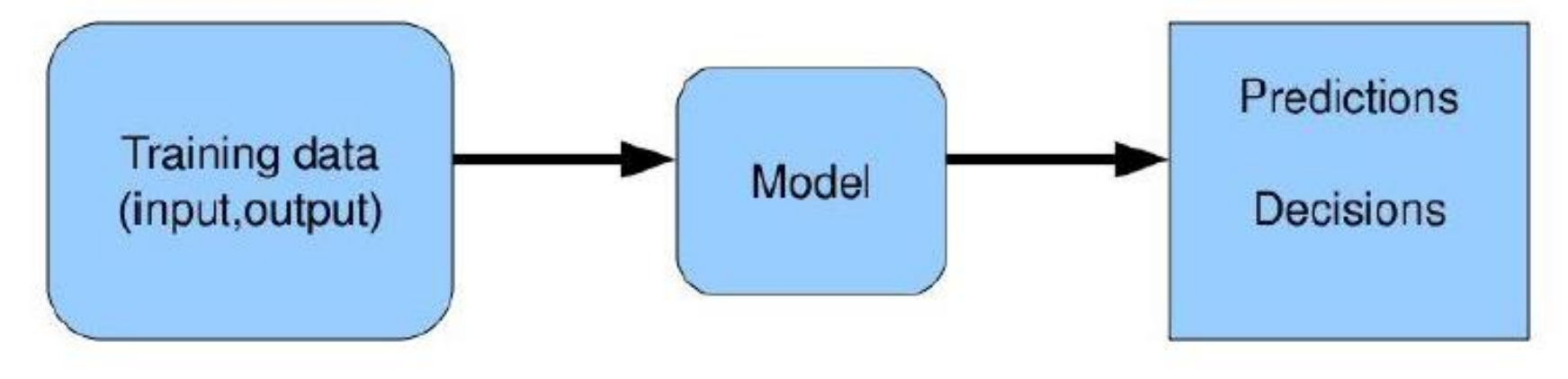
Defect detection - iRVision



Approach: Supervised Machine Learning

Extract features from the images

Deep Learning - Convolutional Neural Networks



Algorithm	Accuracy (mean +- standard deviation)
LR	0.63 ± 0.08
LDA	0.72 ± 0.05
KNN	0.54 ± 0.08
CART	0.75 ± 0.08
Naive Bayes	0.63 ± 0.06
SVM	0.84 ± 0.05
RF	0.86 ± 0.03
CNN	$\mathbf{0.89 \pm 0.07}$

Students involvement

UNIREA

CURIER JUDEȚEAN

Studenții albaiulieni Alin Copîndean și Mihai Golgoț au dezvoltat

APLICAȚIA CARE DETECTEAZĂ FORMA ȘI TIPUL FARFURIILOR PENTRU INDUSTRIA PORȚELANULUI

•Cei doi studenți au cucerit premiul I la cea de-a XIX-a ediție a sesiunii „In Extenso"

Anul acesta, premiul I la secțiunea Informatică a celei de a XIX-a ediții a sesiunii de comunicări științifice a studenților „In Extenso", organizate de către Facultatea de Științe Exacte și Inginerești a Universității „1 Decembrie 1918" Alba Iulia (UAB) a fost acordat studenților Alin Copîndean și Mihai Golgoț, din cadrul universității albaiuliene, ne-a declarat decanul facultății, conf. univ. dr. Corina Rotar.

Cei doi tineri au prezentat proiectul „Metode de vedere artificială și învățare automată pentru clasificarea obiectelor în industria porțelanului", realizat sub coordonarea conf. univ. dr. Adriana Birlutiu.

Practic, ei au dezvoltat o aplicație care detectează și clasifică în mod automat forma și tipul unei farfurii într-o imagine, contribuind la eficientizarea procesului de producție al compa-

nilor din industria porțelanului, prin reducerea cheltuielilor de personal. „Această aplicație are în spate tehnici de inteligență artificială, în particular Deep Learning, o tehnologie de ultimă generație funcțională în multe domenii", a spus Corina Rotar.

Pe viitor, studenții Alin Copîndean și Mihai Golgoț intenționează să îmbunătățească aplicația prin introducerea mai multor categorii de obiecte și să investigheze și alte tehnici de vedere artificială și algoritmi de învățare automată pentru această problemă.

„In Extenso" (Științe exacte și inginerești) s-a desfășurat săptămâna trecută și a reunit peste 100 de participanți, majoritatea studenți din județele Alba, Hunedoara și Sibiu, dar și elevi. Împărțiți pe 6 secțiuni, numai la Informatică fiind înscrise 16 lucrări. *(R.G.)*

Conclusions & Future work

- Integrates robots, artificial vision and machine learning
- Defect detection at different phases of the production process
- Positive economic impact, shorten production time

- Fine-tune the parameters
- Examine the combination of different CNNs
- Change CNN’s structure

Challenges

I. Automatic character recognition in porcelain ware

II. Defect identification

III. Automatic Design and Correction of Ceramic Colors

Current Industrial Process

Key steps in making coloured ceramics:

Largely based on skilled human operators:

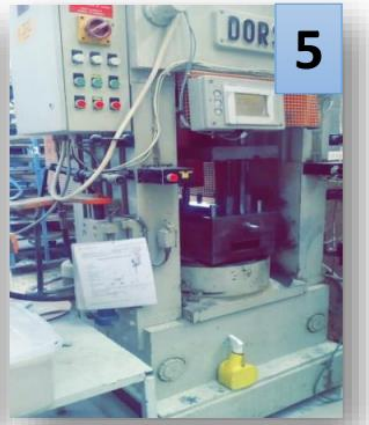
- Costly
- Time-intensive

Machine producing the glaze

Weighing machine to weigh glaze and pigments concentration

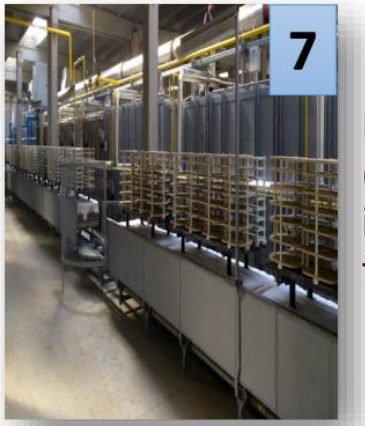
Mixer to mix matte or glossy glaze, pigment & water (various quantities)

Mixtures poured into glasses with different pigment concentrations

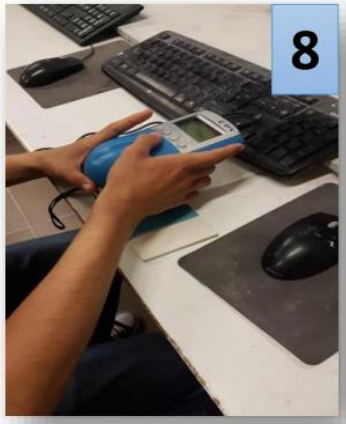


Machine to make biscuits (tiles)

Biscuits dipped into glaze mixtures (matte or glossy, containing various concentrations of pigments)



Biscuits (Tiles) fired in the oven for 6 hours



Colorimeter used to measure the L, a, b of each tile

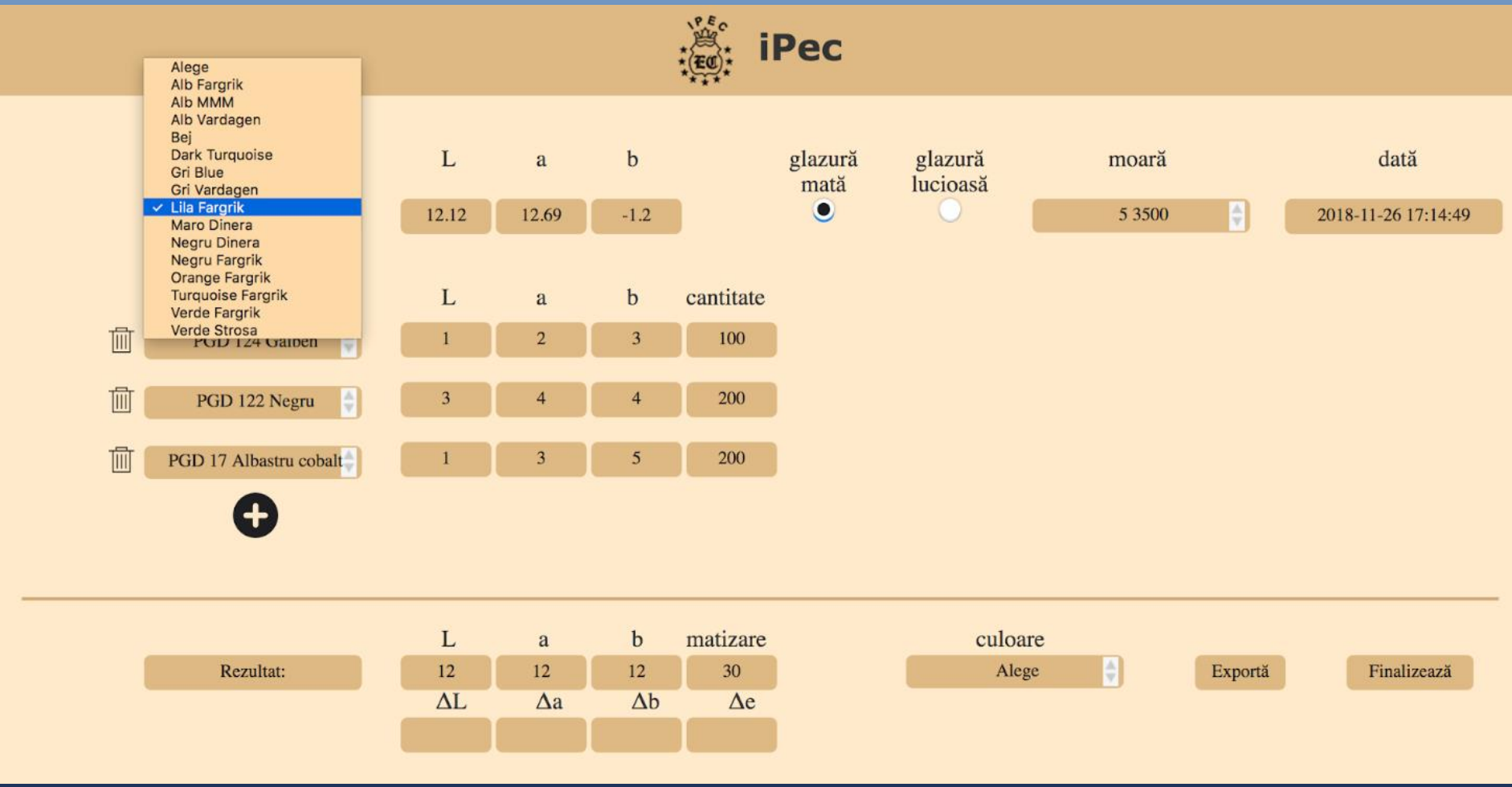
Available data
Regression problem

Comment:	N	Color scale			DL	Da	Db	glazura mata	glazura lucioasa	TTF 3533 turquoise	PGD 128 turquoise	TTF 492 galben	PGD 241 coral	PGD 17 albastru cobalt	1cx13122 galben	SnO2	ZrSio4	PGD 122 negru	PGD 240 coral
04/10/2017 12:45:51pm	1	57.71	22.83	30.66				100				3	3						
04/10/2017 01:57:53pm	1	56.98	22.81	28.48				100				2	3						
04/10/2017 01:57:57pm	1	58.12	21.53	25.41				100				1	3						
04/10/2017 01:58:01pm	1	59.6	20.71	33.19				100				3	2						
04/10/2017 01:58:05pm	1	69.82	10.06	33.63				100				3	1						
04/10/2017 01:58:12pm	1	45.52	4.43	12.79				100		3		3	3						
04/10/2017 01:58:16pm	1	45.13	4.65	10.99				100		3		2	3						
04/10/2017 01:58:18pm	1	45.51	5.06	9.46				100		3		1	3						
04/10/2017 01:58:20pm	1	46.74	8.43	16.34				100		2		3	3						
04/10/2017 01:58:24pm	1	49.42	14.46	21.98				100		1		3	3						
04/10/2017 01:58:38pm	1	47.64	-0.35	12.32				100		3		3	2						
04/10/2017 01:58:44pm	1	50.52	-8.21	11.59				100		3		3	1						
04/10/2017 01:58:51pm	1	66.11	9.4	-5.78				100			3								
04/10/2017 01:58:57pm	1	26.07	14.433	-26.03				100						3					
04/10/2017 01:59:10pm	1	25.93	11.23	-21.56				100			3			3					
04/10/2017 01:59:14pm	1	27.68	12.36	-25.85				100			3			2					
04/10/2017 01:59:21pm	1	30.4	10.96	-27.36				100			3			1					
04/10/2017 01:59:27pm	1	25.16	8.9	-16.20				100			2			3					
04/10/2017 01:59:31pm	1	25.34	11.96	-21.18				100			1			3					
04/10/2017 01:59:35pm	1	25.02	12.04	-20.71				100		3				3					
04/10/2017 01:59:43pm	1	25.86	14.28	-25.45				100		2				3					
04/10/2017 01:59:47pm	1	26.32	14.56	-26.78				100		1				3					
04/10/2017 01:59:53pm	1	27.12	14.72	-28.2				100		3				2					
04/10/2017 01:59:57pm	1	34.64	11.2	-30.7				100		3				1					
04/10/2017 02:00:03pm	1	61.64	-12.26	-11.9					100		3								
04/10/2017 02:00:07pm	1	24.7	9.82	-16.9					100					3					
04/10/2017 02:00:09pm	1	26.73	8.81	-18.8					100		3			3					

Objectives

- Investigate the fundamental notions of color theory (CIE-Lab, RGB)
- Devise a coherent system to collect experimental data from the company in a standard format
- Apply machine learning algorithms to improve the accuracy of the color prediction and correction processes

Data collection



Challenges

I. Automatic character recognition in porcelain ware

II. Defect identification

III. Automatic Design and Correction of Ceramic Colors


thank you!