Incremental Learning Approach for an Industrial Inspection System

MATLAB Expo 2019, Bern

Dr. Jianyong Wen & Ralph Stephan, Stäubli Sargans AG
Stäubli at a Glance

5,000 employees worldwide

1,800 Sales & customer service engineers

1892 Founded in Horgen, Switzerland

29 Business units in 29 countries

1.25 billion Swiss francs (CHF) turnover

12 industrial segments

2,000 pending or granted patents

500 R&D specialists and application engineers
Three activities – four divisions

Connectors
- Fluid Connectors
- Electrical Connectors

Robotics

Textile
Our Textile manufacturing products and services range from

- Shedding solutions for frame weaving and Jacquard weaving to
- Carpet weaving systems,
- Weaving systems for technical fabrics,
- Automation solutions for sock knitting machines,
- Automated weaving preparation systems.
Stäubli Weaving Preparation Systems

- Located in Sargans, SG, since 1994
- ~120 employees (~30 in R&D)
- Product lines
  - Drawing-in
  - Tying
  - Leasing
  - Inspection
Drawing-In
Tying
Leasing, Reading-in and other Equipment
From Idea to Product

1. Idea
2. Model Design
3. Model Verification
4. SoC Integration
5. Integration Test
6. Field Application
7. Data Collection
8. Feedback
Challenges in Embedded Application

- Real-time industrial fabric inspection systems face challenges of a great number of pattern variations, fast and easy training process.
- Strongly imbalanced datasets
- Limitation of hardware resources in embedded systems
The incremental model developed at Stäubli Sargans AG consists of two process stages, combining machine learning and deep learning models.
Development Process

- Developing models
- Optimization parameters
- Functionality test

HDL Code generation

Verification

Efficiency and Speed Test
Preprocessing

Debayer → Resizing → Filtering → Segmentation → Feature extraction
Initial Learning Sub-Model

- Classification based on extracted features from pre-processing

- Corners
- Gray Level Co-Occurrence Matrix
- Edges
- Lawmasks
- Statistical Features
Incremental Sub-Model CNN with 15 Layers

Diagram showing a convolutional neural network (CNN) with 15 layers. The network includes convolutional (Conv.), ReLU, batch normalization (Batch Norm), max pooling (Maxpool), and fully connected (FC) layers. The input image goes through these layers to produce a class output.
Incremental Learning Model in MATLAB
Simulink Design and Simulation
HDL-Code Generation and Resource Utilization Analysis
Advantages

▪ Applicability
  ❖ The CNN sub-model improves classification accuracy during production process (incremental learning).

▪ Efficiency
  ❖ Based on the initial sub-model, the complexity of the CNN sub-model can be reduced (resource and speed efficiency).
Achievements and Outlook

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Benefits and Challenges

- Challenges
  - matching of tools and data sets
  - debugging with blackbox IP
  - limited computing power
  - large databases
Benefits and Challenges

▪ Benefits
  ▪ fast and simple code generation
  ▪ step-by-step implementation and verification (controlled progress)
  ▪ consistent and comparable intermediate results
  ▪ validation of results together with customers
Concluding Remarks

- There are no limits to imagination
- Limits are given by
  - Our knowledge and implementation capacity
  - The capabilities and limitations of our tools
Thank You!

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