Machine vision

Courses: Industrial automation, Automatizace pro průmyslovou praxi

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Introduction

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Machine vision

Machine vision is the technology that enables machines to interpret and make decisions based on visual information from images or video.

It can be understood as a specific instance of data analysis.

Field of application

Machine vision plays a crucial role in:

- Automation
- Quality control
- Robotics

Common machine vision flow

1. Image acquisition
2. Preprocessing / feature extraction
3. Information extraction
4. Taking actions / decision making

It is pretty much similar to any data analysis

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Data for machine vision

- Image (array of values)
- Video (many ordered images)
- Video stream (video in real-time)

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Image

- Image is usually stored as array of numbers
- Integer values are preferred way how to store numbers
- Color images are usually stored as multidimensional array, where every color channel is one dimension

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Image example

Full HD image with 16M colors stored as RGB:

- Array with shape of 1,920 x 1,080 x 3
  (1920 x 1080 = 2073600 pixels)
- Every array cell is unsigned 8 bit integer
  (256 * 256 * 256 = 16777216 colors)

Machine vision tasks

- Detection
- Classification
- Segmentation
- Keypoint search (pose estimation)
- Tracking
- 3D reconstruction

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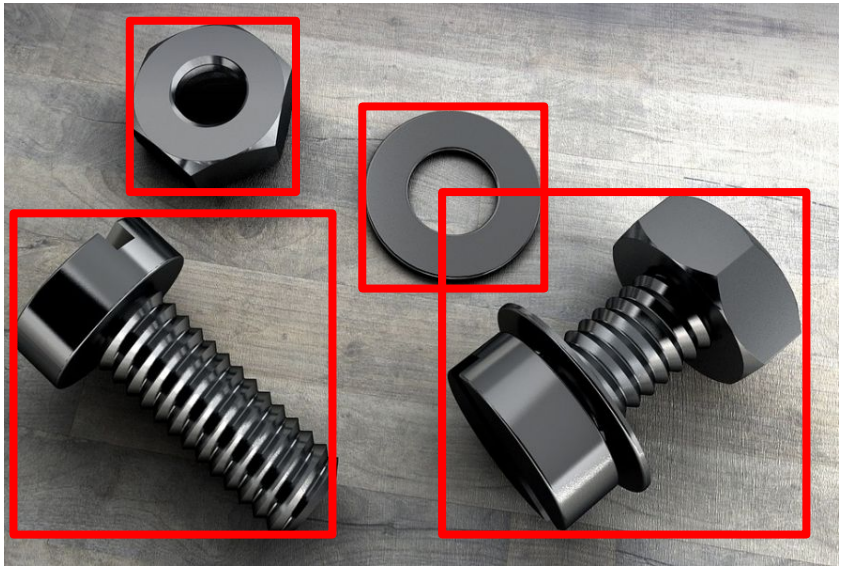
Detection



Detection is the process of identifying and locating objects or specific features within an image.

Classification

Classification is the process of assigning a label or category to an entire object or a region within an image.

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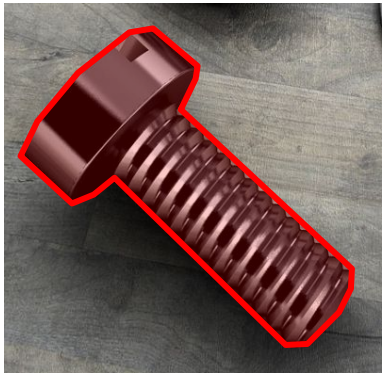
Segmentation



Segmentation is the process of dividing an image into meaningful and visually distinguishable parts or segments

Tracking

Most common approach is:

- Detect possible objects
- Assign objects to previously detected objects

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Common machine vision approaches

- White box (traditional, rule based)
- Black box (Artificial intelligence)
- Gray box (something in between)

Rule based operations

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Common operations

- Thresholding
- Pattern matching
- Morphological operations
- Geometric transformations
- Edge detection
- …

Morphological operations

- **Erosion** shrinks or erodes the boundaries of foreground objects in a binary image
- **Dilation** expands or thickens the boundaries of foreground objects in a binary image.

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Morphological operations

- **Opening** involves performing an erosion followed by a dilation on an image.
- **Closing** involves performing a dilation followed by an erosion on an image.
- **Morphological gradient** is the difference between dilation and erosion, highlighting the boundaries of objects.

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Limitations of traditional processing

- Variable environment (different lighting, etc.)
- Time complexity (online processing)
- Adaptability to different environments (new conditions)

Artificial intelligence

Artificial intelligence (deep learning)

- Very similar to machine learning
- Huge models with many parameters (million+)
- Can achieve similar results to human
- Easy to train and deploy

Artificial intelligence

- It relies on dataset quality and coverage
- AI in machine vision is the only way how to deal with very difficult environment
- Massive improvement in availability and performance in last few years

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Artificial intelligence (deep learning)

- Popular ready-to-use products:
  - YOLO
  - MobileNet
  - VGGNet
  - AlexNet

Limitations of AI

- Data availability
- Data annotations
- Lack of interpretability (industry trust issue)

Summary

AI vs rule based processing

- **Industry future is in AI** (most likely)
- In some cases it is simpler to use traditional processing
- With traditional processing we know what we are doing
- AI handle much more difficult tasks

Machine vision

- Increasing popularity in the last decade
- Machine vision is now understand as a way how to replace other sensors and/or human operators