

Semester project 3

Pallet recognition

API : application programming interface
↓
messenger

- establishes a connection between computer systems and enables data accessibility
- allows monitoring users and their activity

Object recognition software

there is also object detection,

↓
object identified and located in an image

Approaches

1. machine learning

3. template matching

2. deep learning

4. image segmentation

<https://se.mathworks.com/solutions/image-video-processing/object-recognition.html>

and blob analysis

Deep learning

- there are already learning models
 - { convolutional neural networks →
 - **CNNs**: by analyzing thousands of training images and learning the differences
- 2 approaches:
 - training a model from scratch: gather a large labeled dataset and design a network that will learn the features and build the model
requires a large amount of training data
set up the layers and weights in CNN
 - using a pretrained deep learning model:
most applications use the transfer learning approach → involves fine-tuning a pretrained model. Start with an existing network:
AlexNet or **GoogLeNet**

and feed in new data contains previously unknown classes

less time-consuming, faster outcome

Machine learning

techniques :

1. HOG feature extraction with an SVM machine learning model
2. Bag-of-words models with features such as SURF and MSER
3. the Viola-Jones algorithm which can be used to recognize a variety of objects, including the faces and upper bodies

machine learning offers the flexibility to choose the best combination of features and classifiers for learning.

ACCURATE RESULTS WITH MINIMAL DATA

Which can be chosen?

Deep learning → better with more images

GPU helps to decrease the time needed to train the model

template matching



uses a small image or template to find matching regions in a larger image

image segmentation and blob analysis



uses simple object properties such as size, color or shape

Object recognition with Matlab

↳ Deep learning and Machine learning

Why matlab?

1. Matlab makes learning about those fields practical and accessible. Also enables domain experts to create object recognition models



2. Classification learner app: build machine learning models and compare different machine learning algorithms



Image labeler app: for training and testing deep learning models

3. Matlab can unify multiple domains in a single workflow. It has tools for machine and deep learning, robotics, computer vision and data analytics

Difference between machine learning and deep learning?

Deep learning is a specialized form of machine learning

<https://surjeetsaikia.medium.com/object-detection-for-robots-using-deep-learning-68c660aa3b96>

Object detection using deep learning

object detection algorithm

↓ trained with

Google open image dataset

→ can detect more than 600 object categories

→ Depends on Python 3.

- **TensorFlow - 1.12.0**
- **Keras 2.2.4**
- **Open CV3**

<https://www.rsipvision.com/object-detection-methods-for-robots/>

Object detection methods for Robots

track motion using video successive frames

Self-navigating robots use multi-camera set-up and a set of image generating sensors

the computer vision system employs data fusion during or post the object detection algorithms.

Provides the following information

} localization

} type

} motion attached to each object

Classical object detection methods

template matching algorithms

↳ structured matching process

- 1st : object parts are recognized
- 2nd : globally matching uses the
partial matches

statistical classifiers such as

Neural Networks, AdaBoost, SVM,

Bayes were used to enhance the
recognition, where variation existed

Object detection algorithms →
Multi-resolution models

Object detection methods for robotics equipment

1. boosted cascade classifiers : eliminate image segments that do not match some predefined object
2. dictionary-based object detection algorithms : check the presence of a single class in the image
3. CNN : Convolutional Neural Networks
the algorithms that belong to this group learn the objects features rather than being programmed with them. But they need a large amount of data to achieve their performance

5. Structured algorithms:

algorithms of this group may form abstract object detection machine

According to blog:

To make a robot detect a pallet

1. Sensor integration: cameras, LiDAR,
or other proximity sensors

2. Point cloud method:

This method uses 2D range data to label the region of interest (ROI). The pallet's features are then extracted, provides precise localization of the pallets

3. Deep Neural Network (DNN):

applied to detect and locate the pallet in the RGB images. DNNs recognize various types of pallets.

4. RGB-D sensor:

used to recognize and locate pallets in a warehouse environment

5. Pallet identification and localization

Algorithm (PILA) :

uses RGB image and Point cloud data
to balance the localization precision and
running time with low-cost hardware



<https://crgjournals.com/robotics-and-mechanical-engineering/articles/pallet-localization-techniques-of-forklift-robot-a-review-of-recent-progress>

<https://www.mdpi.com/2076-3417/12/20/10331>

Links used

bixy :

Hardware for robot pallet recognition

1. 2D laser rangefinder :

Used in the point cloud method and
PILA for detecting and localizing
pallets 600 \$ 300 \$

2. RGB-D sensor :

Provides both color (RGB) and depth (D)
data which can be used for object
recognition and localization 109 \$

3. Robotic Arm

TOO EXPENSIVE

https://www.festo.com/in/en/c/products/industrial-automation/pneumatic-grippers-id_pim227/

4. Grippers :

17 \$ mini Kit ↑

Attached to the robotic arm and are

used to pick up and move pallets

<https://www.amazon.com/grippers/s?k=grippers>

5. Infeed / Outfeed stations : These are locations where the pallets are picked

MP (infeed) and placed (outfeed).
They need to be defined in the robot's
environment

Hall effect sensors

2 types of magnetic sensors :

- { Hall effect sensors : solid state transducers convert magnetic energy to electrical energy
- reed switches : electro - mechanical

Magnet-based sensors are commonly used to track rotations in DC electric motors

Hall effect

magnet repels negative charges to one side of the conductor creating an asymmetric distribution of charge on the conductor. This separation of charge establishes a new electric field with a small electric potential. Current continues to flow even in the presence of a magnetic field.

Hall effect sensors

Use the Hall effect to measure the magnitude of a proximal magnetic field. They work with static fields. They can respond to a magnet even if it's not moving.

inductive sensors → respond to changing magnetic field

Hall effect sensors can provide either analog or binary output. They are active sensors with 3 pins (V_{cc} , GND, and out).

Hall effect sensor outputs a varying voltage

Some hall effect sensors act as switches:

USS9D1LUA switches to low in the presence of a south magnetic pole

Some Hall effect switches are latching

↳ remain in their activated state even when the magnet is removed. For example

US1981 → switches to high in the presence of a north magnetic pole but remains in that state until a south magnetic pole is sensed

Reed switches

electromechanical devices. Is a passive sensor: its contacts will close in the presence of a magnetic field regardless of it's ever hooked up in a circuit.

the magnetic field has to be parallel to the reeds

According to Google

types of sensors that can be used in automated forklifts for pallet detection

SENSORS

1. camera (monocular or stereo) : These sensors use cameras to capture images of the environment and then use computer vision algorithms to detect pallets

2. 2D or 3D time of flight laser Range Finder (LRF) :
these sensors emit laser beams that bounce off objects and return to the sensor - the time it takes for the beam to return is used to calculate the distance between the sensor and the object.

3. Ultrasonic sensors : you can determine whether a pallet is on the fork and how far the fork is inserted under the pallet

11. KUKA. Pallet tech is a software for palletizing that enables an user friendly configuration and execution of palletizing tasks with various packing patterns and stations

types of sensors that can be used to detect the presence of an object

1. electro-mechanical limit switch: contains a sensitive micro switch that changes state when a mechanical actuator is displaced by the detected object.
2. Pneumatic sensor: utilize compressed air and a sensitive diaphragm valve to detect the presence of objects. This pressure change is detected by a downstream diaphragm switch that produces an electrical control signal.

3- capacitive sensor: detect objects by measuring changes in capacitance caused by the presence of an object in their sensing area. They are ideal for detecting non metallic objects such as liquids, plastics and powders.

4- photoelectric Sensor: use light to detect objects and can be used to detect objects of various shapes, sizes and colours.

5. Inductive Sensor: detect metallic objects such as screws, bolts and metal parts.

6. Ultrasonic Sensor: detect objects of various shapes, sizes and material.

extraction of image features
that match the target image or frame

→ neural networks and deep
learning classifiers

many modern classifiers are
based on CNNs

CNNs : deep neural network

↓
type of deep learning algorithm
used for analyzing and processing images

CPU: runs the software for the image processing

GPU: used to accelerate certain computations such as matrix operations that are common in image processing

Boosted cascade: machine learning approach

classifier: algorithm that automatically sorts or categorizes data into one or more classes

- types:

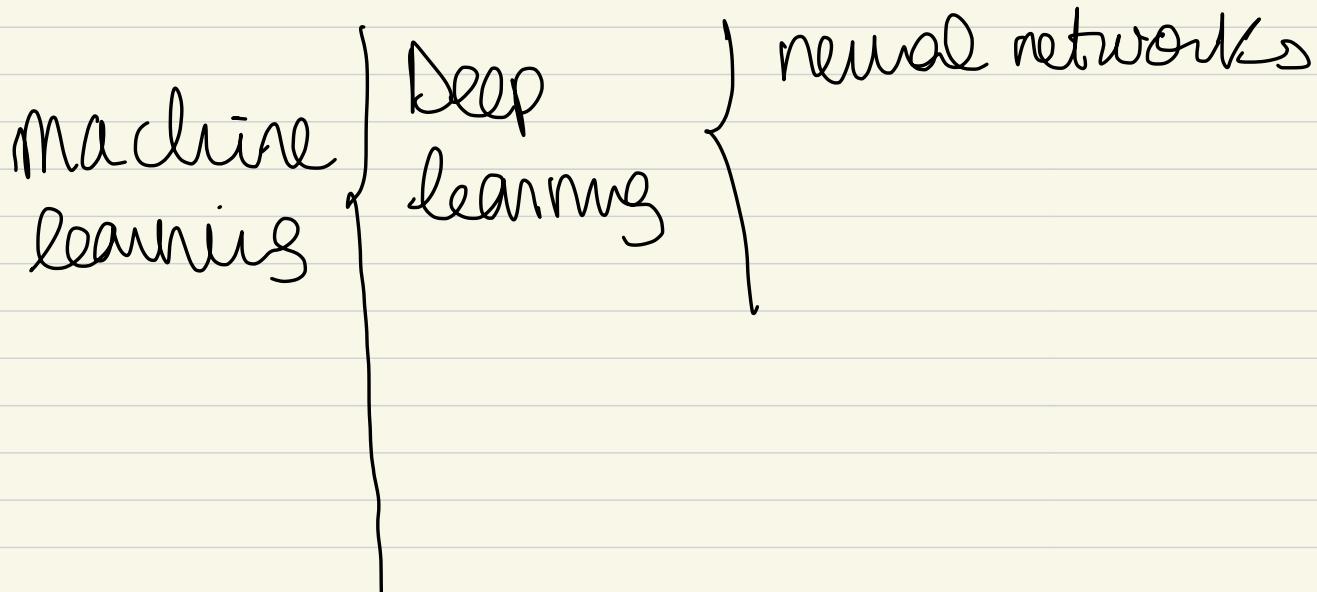
- Naive Bayes
- K - Nearest neighbor
- Decision tree
- Artificial Neural Networks
- Support Vector Machine

Bag of words model (BoW model) :

treats image features as words

Point cloud method: creates a representation of a 3D object with densely placed points along its surface

- ↳ 3D scanners
- ↳ photogrammetry software



LiDAR: remote sensing technology that uses laser light to measure distances and creates 3D models of objects

RGB-D sensors: depth camera

PILA: uses computer vision and deep learning algorithms to detect and locate pallets in real-time

2D laser rangefinders: distance measurement device that uses laser light to measure distance in 2D

PALLET RECOGNITION

A Deep Neural Network (DNN) method can be applied to detect and locate the pallet in the RGB images. Using PILA to detect and locate the pallet and a vehicle alignment algorithm (VAA) to align the vehicle fork arms with the pallet.

VAA: works in conjunction
with PILA

Both algorithms are implemented
as follow:

1. PILA : uses a low cost RGB-D
camera to recognize the pallet.
DNN method is applied to
detect and locate the RGB images.
The point cloud data is concatenated
with the labeled region of interest
(ROI) in the RGB image, and the
pallet's front-face plane is extracted
from the point cloud

2. VAA : this algorithm is used to implement the vehicle approaching and pallet picking operations.

The source code for PLA and VAA can be found on GitHub
The source code is written in C++

Fork Grippers

MARKeT research

<https://www.lacconveyors.co.uk/how-intelligent-pallet-conveyors-drive-warehouse-efficiency/>

enhanced accuracy and traceability

increased throughput and productivity

safety and workforce optimisation

Hall effect sensors

type of non contacting position sensor.

<https://www.progressiveautomations.com/blogs/products/the-pros-cons-of-feedback-devices#:~:text=Hall%20Effect,-Hall%20effect%20sensors&text=For%20this%20reason%2C%20they%20are,only%20provide%20relative%20position%20information.>

Reed switch

activated

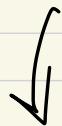
type of electrical switch ↗

turned on and off or change

over by magnetism

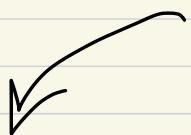
<https://www.rfwireless-world.com/Terminology/Advantages-and-Disadvantages-of-Reed-Switch.html>

<https://inria.hal.science/hal-02557329/document>



Detection and tracking of
pallets using a laser Rangefinder
and machine learning techniques

<https://acroname.com/blog/selecting-sensor-technology>



Laser rangefinders

Scanning LiDAR

Infrared led rangefinders

Short range radar