SPRING TERM PRESENTATION

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ELIAS ALBAG
HANNA BEATTY
THEO BYSTRÖM
MARKO GVERO
VICTORIA HELLSTRÖM
CHRISTIAN HJERPE
MARKUS LINDGREN HARDELL
NIKLAS NYBERG
HANNA SENNERÖ

VOLVO

THE TASK

- A lot of the work being done on construction sites is grading *(flattening of ground)*
- Making excavator operating easier
- Allows less experienced operators to do difficult tasks

VOLVO

KICK-OFF

- Operated excavators ourselves
- Together with the Volvo engineers, concluded a shared understanding of the problem
- Initial part of a larger, long-term development - also tasked with defining the initial framework and system architecture.

DESIGN BRIEF

Project Description:

- From: Two-lever manual control
- To: *Single-input bucket tip control*

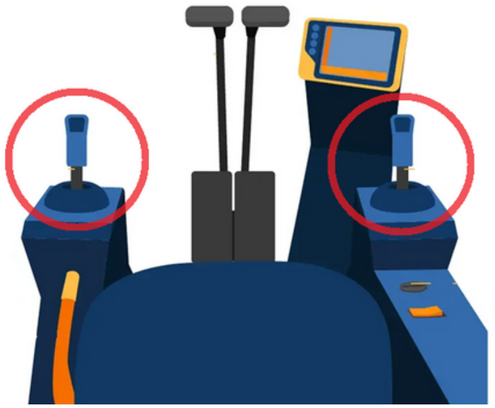
Includes:

- Simulation environment selection
- Control method
- Sensor selection & system design

Goal:

Enable smooth bucket motion for **grading** and **lifting**, without requiring expert operator skills.

Generation shift.



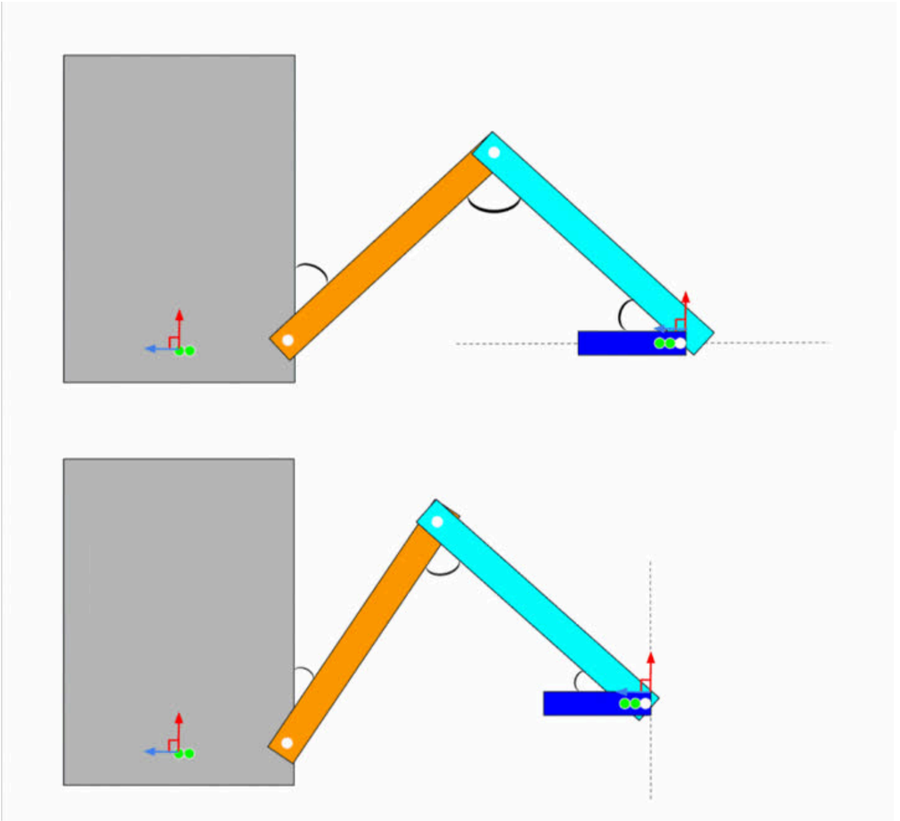
Picture: bigrentz.com

PROJECT SPECIFICATION

REQUIREMENTS - STAKEHOLDERS

From a flat, level surface, should be able to perform movements in the X and Y directions:

- *X-direction:* Grading
- *Y-direction:* Lifting



Accuracy requirements

- ±5 mm (in 2 dimensions)

Code reqirement:

- Well-commented
- Well-structured

Achieve reliable results consistently:

- During continuous operation
- While being subjected to disturbances

ORGANIZATION

- Modelling
- Control
- Implementation

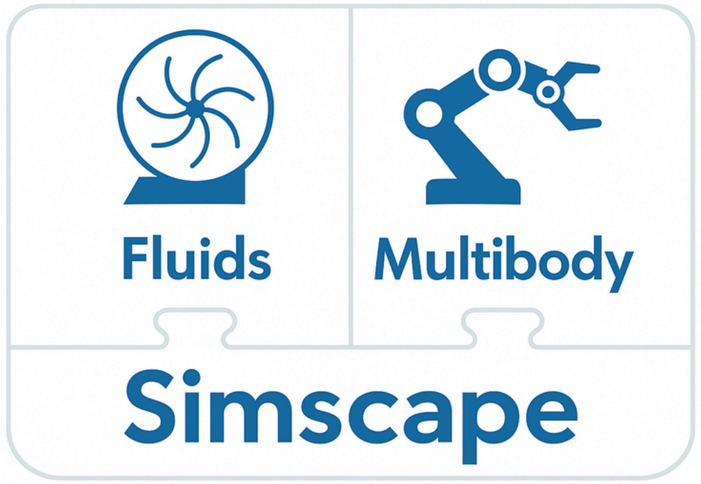
MODELLING

Two approaches

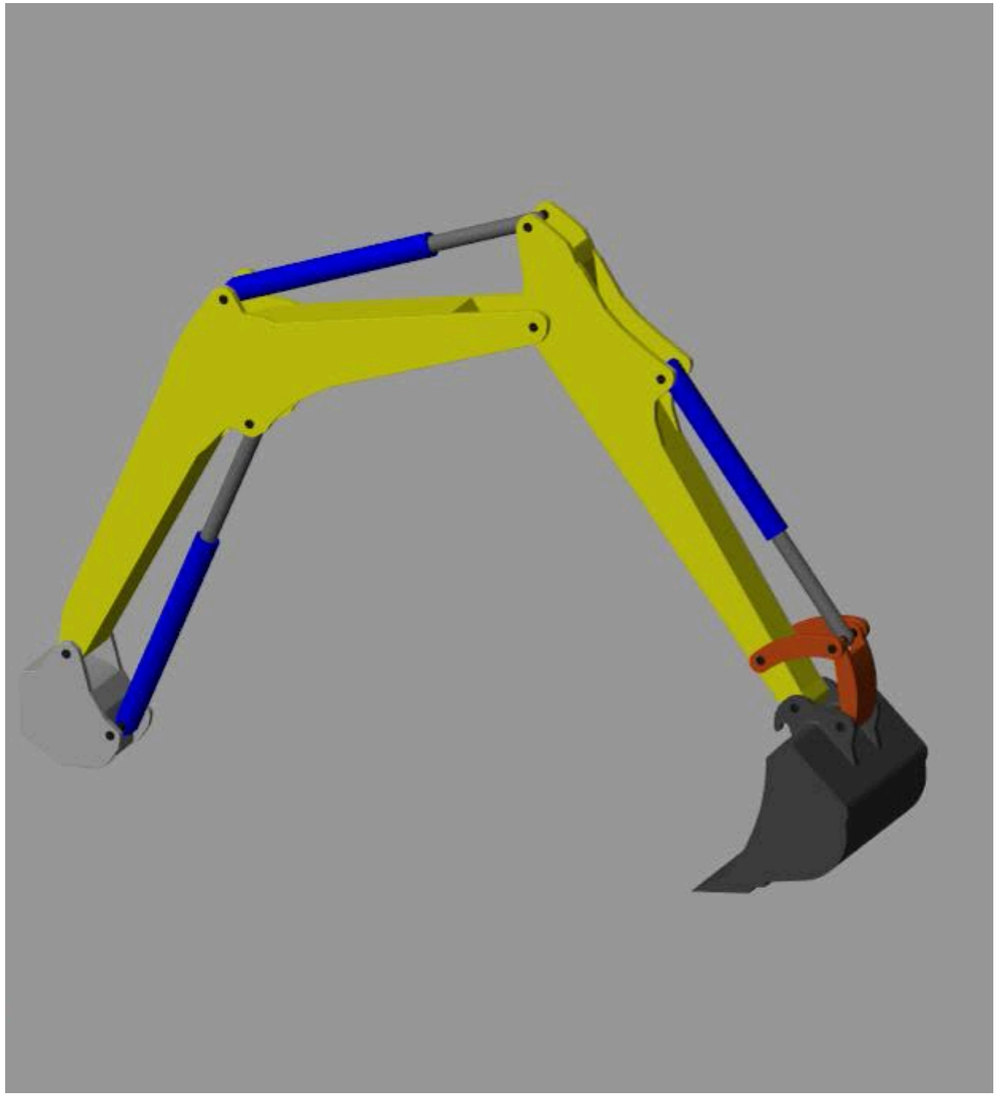
- Simulink
- Machine Learning Approach

MODELLING

- Simulink



Multidomain implementation in Simscape

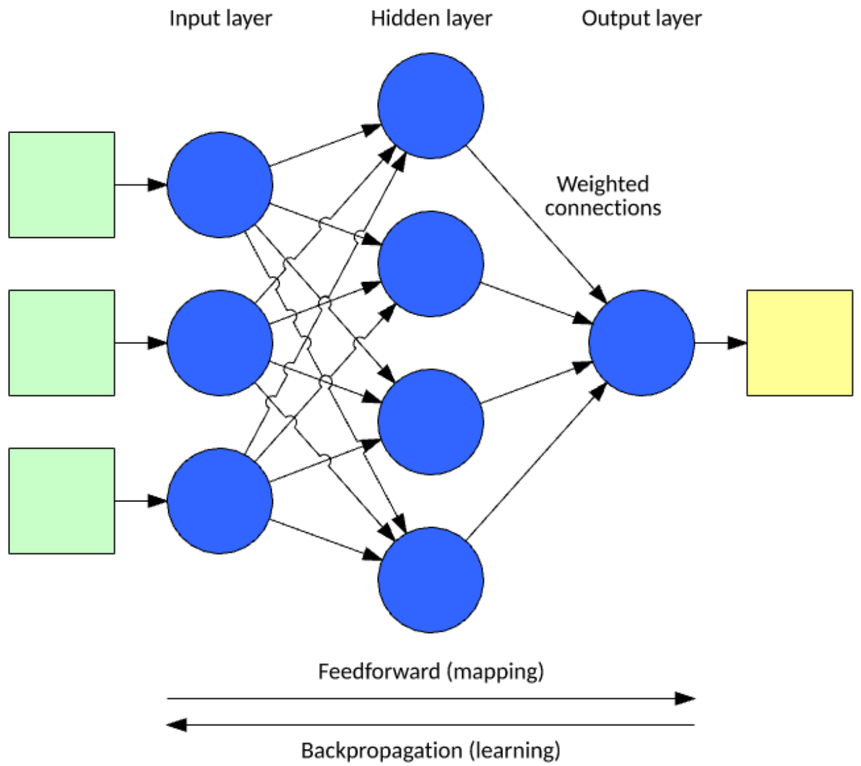


MODELLING

Machine Learning Approach

- Simscape (physics-based) vs. Machine learning (sensor data-based)

- Accounts for system imperfections
- 3-layer Neural Network with backpropagation
- Future potential / hybrid approach

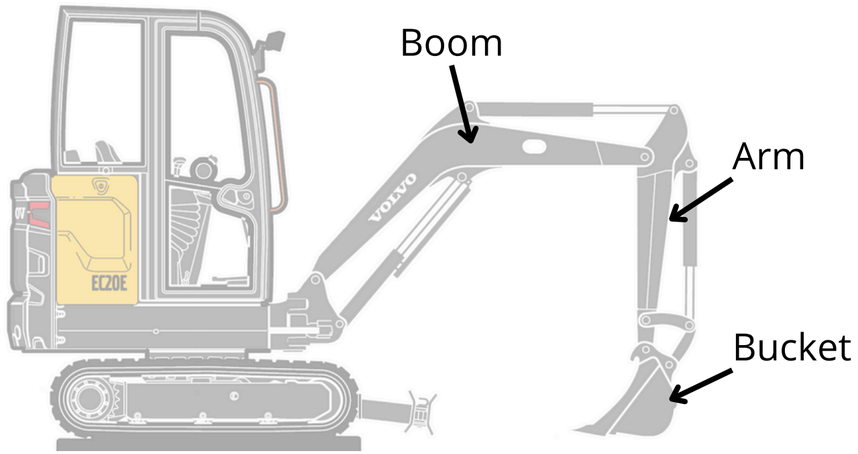


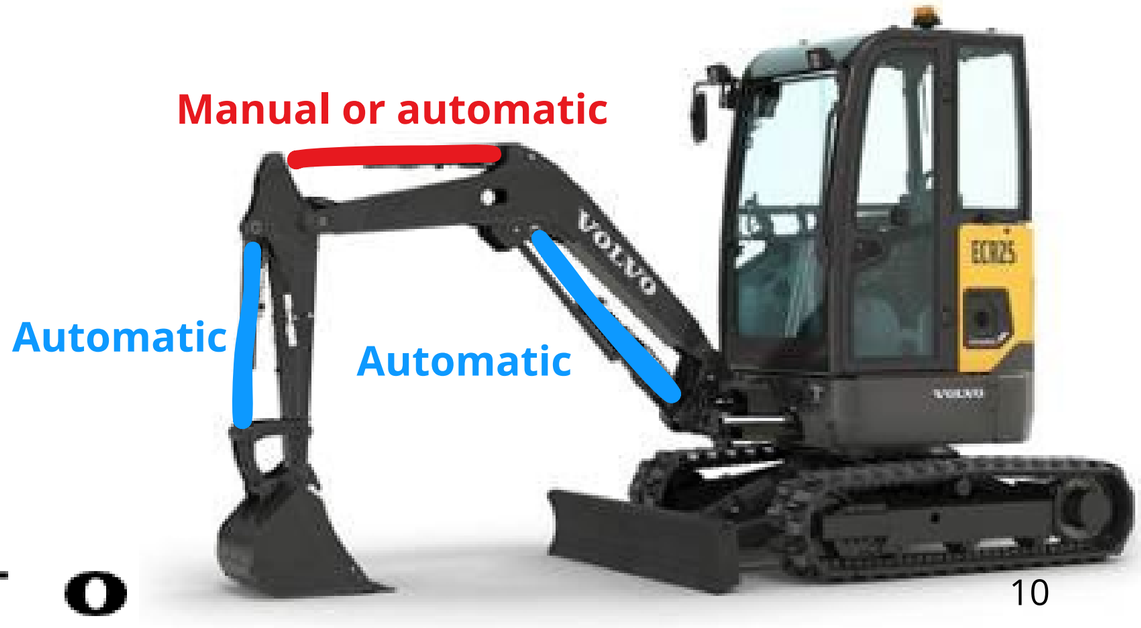
CONTROL

Automatic ← OR → **Semi automatic**

- Operator controls bucket reference velocity
  - System controls **bucket** for angle
  - System controls **boom** for height/speed
  - System controls **arm** for height/speed

- Operator controls arm movement
  - System controls **bucket** for angle
  - System controls **boom** for height

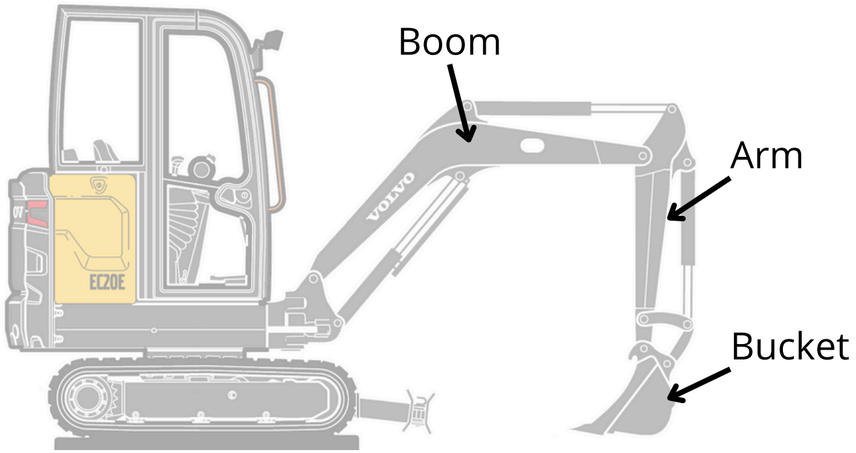


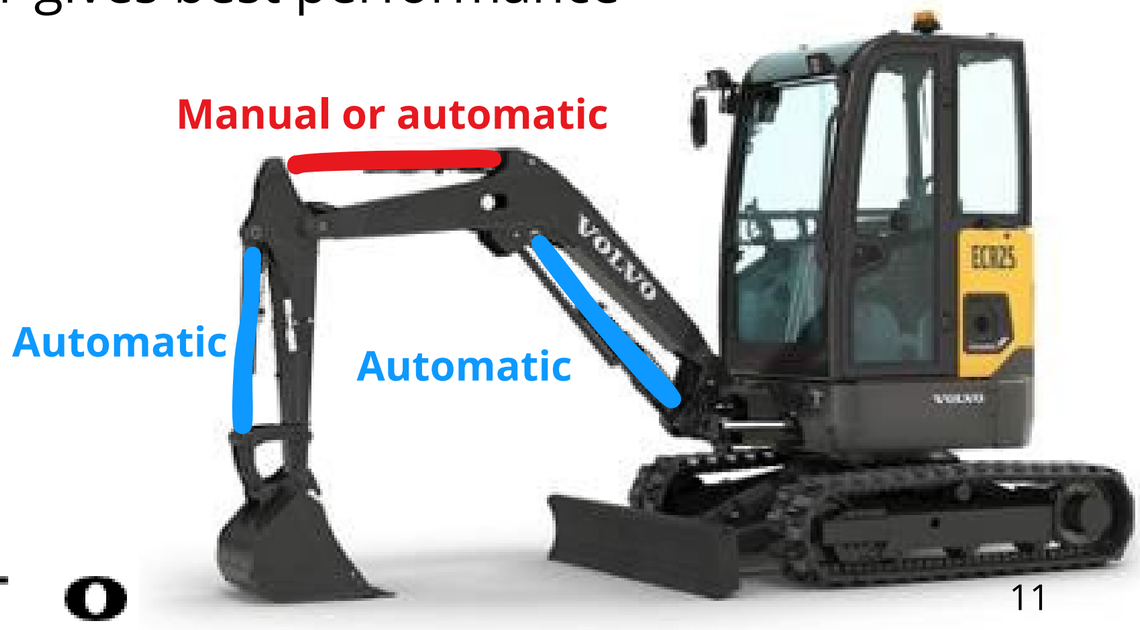


VOLVO

CONTROL

- Start with PID and feed forward control of angular velocities
- Velocity control → Bucket will drift → Additional feedback is needed
- Hydraulics and linkages → Non linear → PID might be insufficient
- SOTA → Neural networks based controller gives best performance





VOLVO

SENSORS

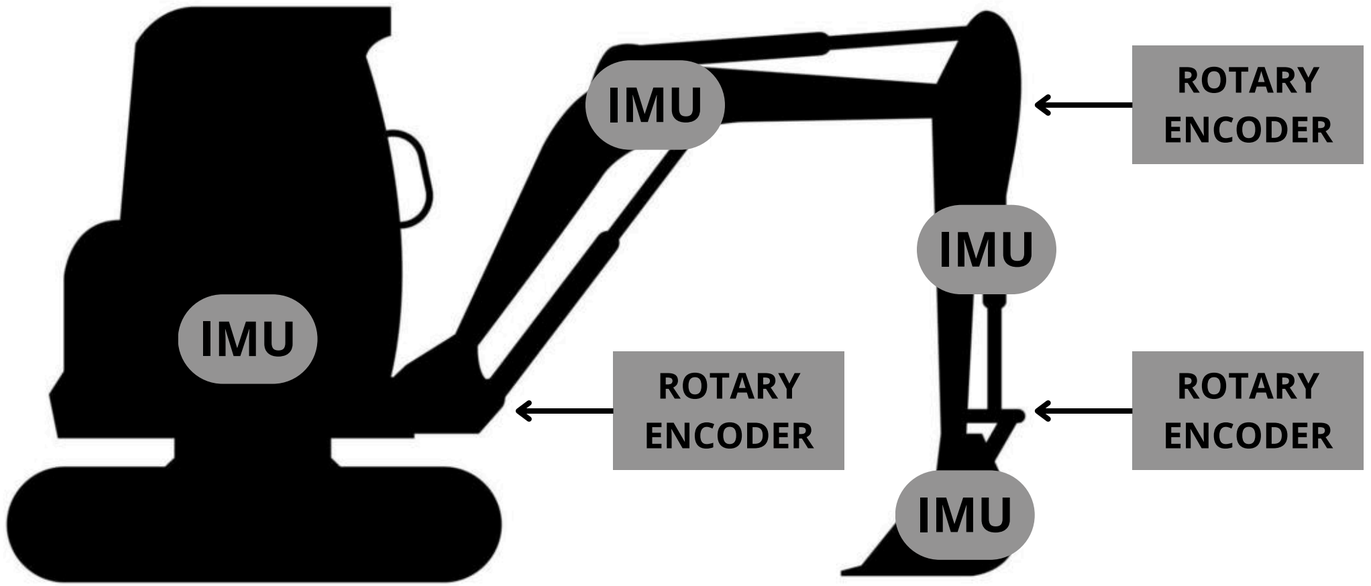
Goal:

- System accuracy of ±5 mm
- Withstand harsh environment

- Inertial sensors: accelerometers, gyros, and IMUs.
- Inclinometers
- Rotary encoders

VOLVO

SENSORS


IMU
IMU
IMU
IMU
ROTARY ENCODER
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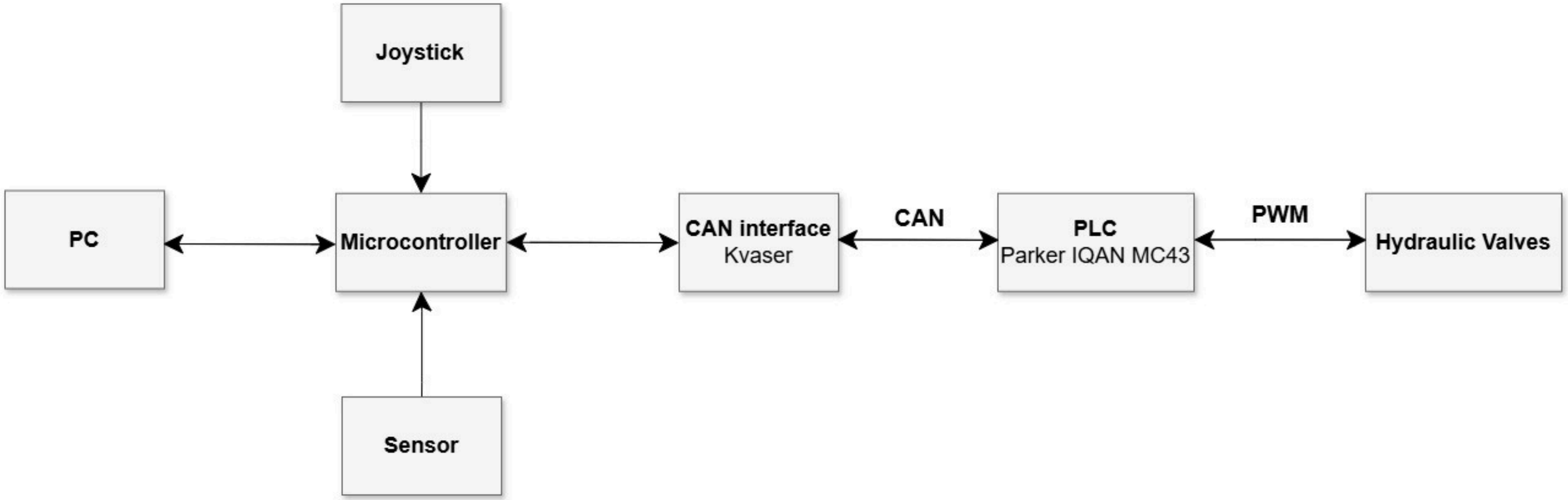
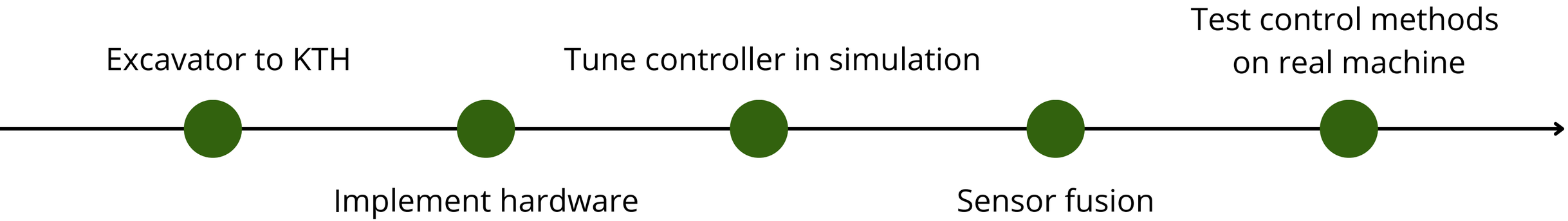
SYSTEM ARCHITECTURE



AUTUMN TERM


Excavator to KTH
Implement hardware
Tune controller in simulation
Sensor fusion
Test control methods
on real machine