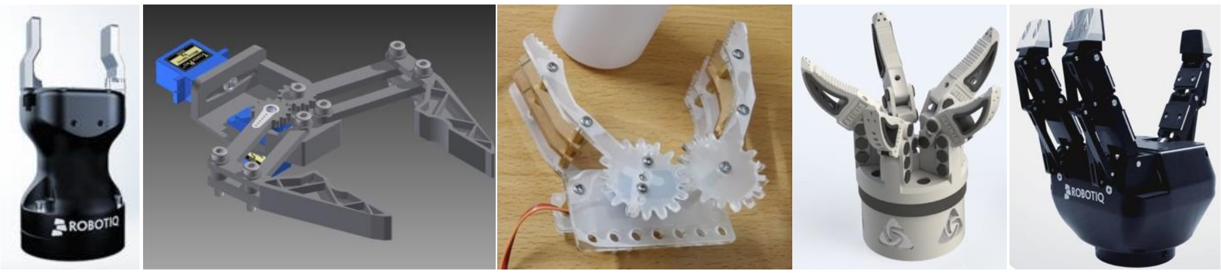
RB-PRO2 - UR Gripper

(Semester Project in Autonomous Robots)



A gripper for the Universal Robots UR5 robot is to be developed during this semester project.

Your task is to build a physical gripper that can be controlled (open/close/…) from the UR robot and that can deliver measurement data to the PC. The data is to be visualized on the PC. The ATMega board will play the central role of controlling the actuators and sensors and communicating with the other parts.
Design your gripper to match a specific use case. An example use case is given in the end of the document.

In the following the specific project requirements are given.

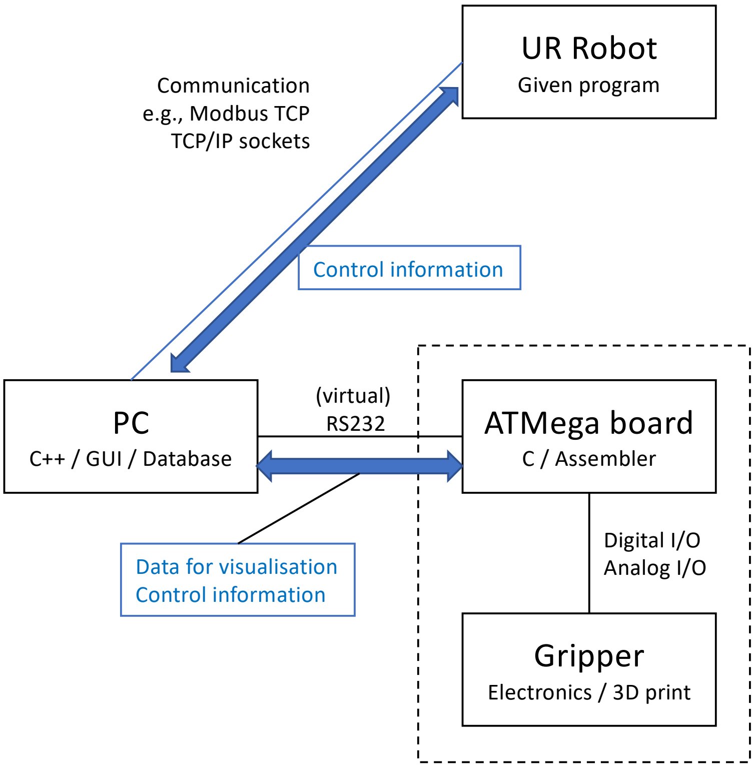
Requirements

1. Develop a 3D model of a gripper that can be printed or otherwise constructed.
2. Use the electronics given to control the gripper and read the motor-current.
3. Develop C++-program that:
    - Provide an interface for a user to define a task description (e.g. where objects are to be grasped from). This should include:
        - World to robot frame transformation of coordinates by a calibration between table and robot.
        - Manual implementation of a transformation between the robot tool flange and the gripper grasping point.
    - Uses Modbus TCP to receive gripping commands from / give status information to the UR robot, e.g.,
        - Close / open gripper commands
        - Gripper fully closed feedback
        - …
    - Uses RS232 to talk to gripper to
        - forward the commands gotten from the UR robot
        - receive data, e.g.:
            - Motor-current
            - Gripper opening
            - The no. of grips
            - …
    - Visualizes the measurements/information.
4. Develop Software (C or Assembler) for the ATMega that:

- Communicates with the PC-program to
  - receive commands from the PC, e.g.,
    - Close / open gripper commands
  - and sends data back to it, e.g.,
    - Gripper fully closed
    - Other information (mentioned under 3)
- Controls the developed gripper hardware.

5. Test and document the performance of your gripper. Examples for experiments could be:
   - Perform sufficient amount of pick and place operations with the physical robot and document the grippers performance in terms of successes and any failures that might occur.
   - Document the grippers load lifting capacity. This can vary with object shape, density, friction properties, volume, etc.
   - Document closing and opening times to determine speed.
6. Document the use of management tools/strategies for the project.

Your implementation should correspond to the block diagram below:



Nice additions could be:

- Computation of aggregated data (e.g., average motor current)
- Anomaly detection (to high currents, too long time => grasp failed)
- Addition of more sensors (e.g., an end stop switch for the gripper opening)
- Come up with your own use case
- …

The gripper must fulfil the following requirements:

- Supply voltage: 24V (from external supply – you are not allowed to use the robot controller as power supply)
- The maximum gripper power use: 600mA
- It is not allowed to use the digital I/O from the UR robot. All I/O must be done through the ATMega board. Please remember that the power output from digital I/O is very limited.

Hand-in

Project must be handed in electronically on Digital Exam.

You must hand in **one PDF file (max 10MB)** with the report and **one zip-file (max 10MB)** on *Digital Eksamen* with appendices and source code, Mathematica/MATLAB code, test documentation, supplemental material etc.

Latest hand-in is Friday May 24th 2024 at 10:00. The system automatically closes for hand-in.

Evaluation

The final evaluation will be based on the following:

- Fulfilment of requirements
- Implementation of ideas and innovative solutions
- Documentation and individual examination of the project

Resources

- DevLab http://devlab.sdu.dk
- SDU Library FabLab http://www.sdu.dk/da/fablab
- Actuators
  - Motors on request (from the below list)
    - https://dk.rs-online.com/web/p/dc-motorer-jaevnstromsmotorer/9211464/
    - https://dk.rs-online.com/web/p/dc-motorer-jaevnstromsmotorer/9211458/
    - https://dk.rs-online.com/web/p/dc-motorer-jaevnstromsmotorer/9211442/
  - Push/Pull type electromagnet (JF-0826B)
- RS Online (small components can be ordered by supervisor – within reasonable limits)
- Modbus RTU library for ATMega, e.g.,
  - https://www.embedded-experts.at/en/freemodbus/ports-ascii-rtu/avr-atmega8-16-32-128-168-169/
  - (and a lot of other libraries)
- Modbus library for PC:
  - https://libmodbus.org/
- Modbus GUI for testing:
  - https://github.com/SciFiDryer/ModbusMechanic
- ATMega644PU datasheet
  - https://ww1.microchip.com/downloads/en/DeviceDoc/ATmega164A_PA-324A_PA-644A_PA-1284_P_Data-Sheet-40002070B.pdf
- ATMega32 migration guides
  - https://ww1.microchip.com/downloads/en/AppNotes/doc8001.pdf
  - http://ww1.microchip.com/downloads/en/Appnotes/doc8190.pdf
- UR tutorials:
  - Generic tutorials: https://www.universal-robots.com/academy/
    - Find free e-learning
    - CB3 robots
- UR simulator:
  - https://www.universal-robots.com/download/software-cb-series/simulator-non-linux/offline-simulator-cb-series-non-linux-ursim-3142/
- UR documentation
  - https://s3-eu-west-1.amazonaws.com/ur-support-site/77419/99202_UR5_User_Manual_en_Global.pdf

Group members

If group members decide to stop their studies or if group members for some reason are excluded, the group must e-mail Kamilla Juel Sørensen (kjs@tek.sdu.dk). You need to tell which person has dropped out followed by the reason given. Please discuss the case with your supervisor.

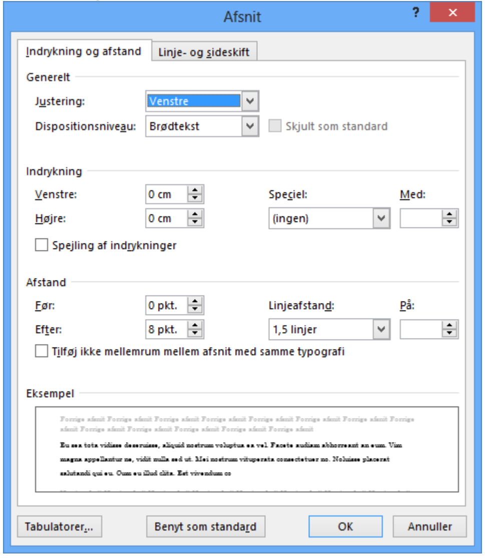
In case of an inactive group member, please follow this procedure:

- Try to contact the group member using the student e-mail and set your supervisor as “cc” in the e-mail.
- Also try to reach the group member with other communication media phone, Facebook, etc.

If it is impossible to get in touch with the group member, please discuss the case with the supervisor and send an email about the case to Kamilla Juel Sørensen (cc: the supervisor). She will then try to contact the inactive person. If the person is not eligible to be a part of the group, procedures will take action to exclude the person from further project work.

Requirements to the report

The report must be written in English (unless your supervisor instructs you in Danish). The report needs to be written with footed fonts (e.g., Times New Roman, Century Schoolbook or equivalent). Top and bottom margins must be 3cm and side margins must total to 6cm (e.g., 2.5 and 3.5cm). It is recommended to keep one margin a bit wider than the other to keep room for notes.



Afsnit

Indrykning og afstand | Linje- og sideskift

Generelt

Justering: Venstre

Dispositionsniveau: Brødtekst □ Skjult som standard

Indrykning

Venstre: 0 cm

Højre: 0 cm

Speciel: (ingen)

Med:

□ Spejling af indrykninger

Afstand

Før: 0 pkt.

Efter: 8 pkt.

Linjeafstand: 1,5 linjer

På:

□ Tilføj ikke mellemrum mellem afsnit med samme typografi

Eksempel

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A line spacing of approximately 1.5 is recommended. The accurate line spacing and font size is determined using the lorem ipsum text on the last page. The lorem ipsum page is supposed to take up a complete A4 page with the given margins - no more, no less. The lorem ipsum page is written with Century Schoolbook font size 10, spacing of 8pt. after a section and line spacing of 1.5.

With these settings the report has a maximum page count of 30 pages (all inclusive). This is not a minimum, but a maximum. A good project does not need to be 30 pages.

The distribution of tasks among the group members must be stated in the report.

The agile development process used must be documented.

The class structure of your C++ / PC program must be documented.

The report front page must give a title, education, semester, group number, authors with birthday (NOT your CPR-number) and username, the name of your supervisor and the supervisor's e-mail.

Example case: Packaging of Lego bricks

Note: This is an example case, you are welcome to come up with your own test case.

A factory is producing 3 types of Lego bricks, on 3 different production lines. Currently, the Legos are packed manually at the end of the production line. For this case, you should design your gripper so that it can pick up all three types of bricks.

You should demonstrate the grippers capabilities by creating a robot setup to automatically package the bricks into boxes for shipping.

We have a bunch of Lego bricks in size 2x2, 4x2 and 6x2, as well as some fixtures that simulate the end of the production line. As a starting point, one of each brick should be picked up from the fixture and packed in each box. However, you are welcome to extend the system so that it can pack an arbitrary amount of each brick type into the box.