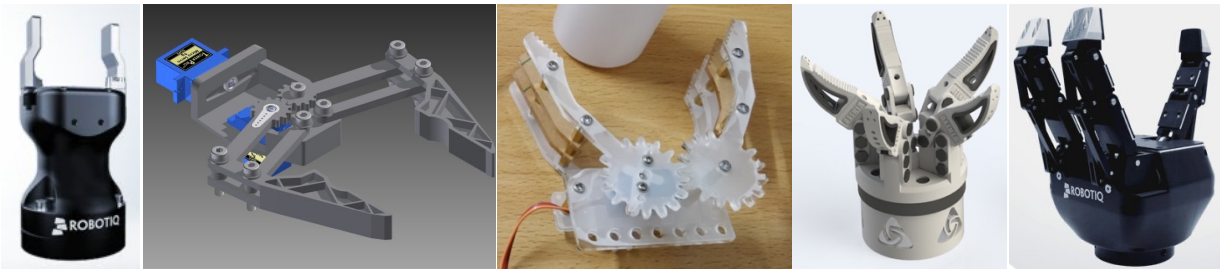
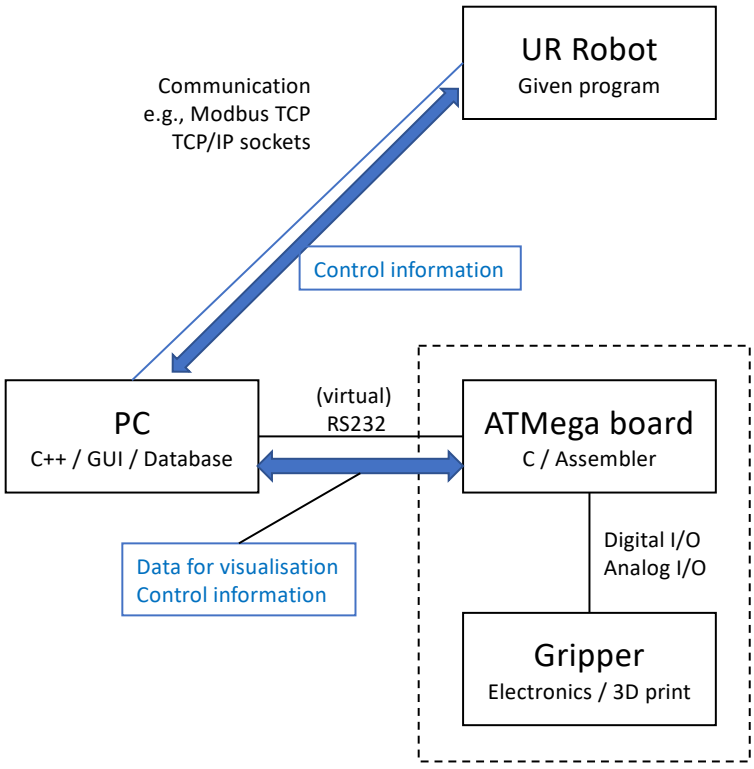
Digital UR Gripper

(Semester project 2nd semester BSc. RobTek)



A gripper for the Universal Robots UR5 robot is to be developed during this semester project. An idea could be to follow the block diagram below.



Your task is to build a physical gripper that can be controlled (open/close/…) from the UR robot and that can deliver measurement data (e.g., currents) 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. In the following the more detailed requirements are given.

Requirements

It is expected that you at least:

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 current measurements
3. Develop A PC based software in C++ that:
    - Uses a communication protocol (e.g., 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 some communication protocol (e.g., RS232) to talk to gripper to
        - forward the commands gotten from the UR robot,
        - and to get information, e.g.,
            - The no. of grips
            - Gripper force
            - Gripper distance
            - Motor current during gripping
            - …
    - Saves the information/measurements from the gripper in a database.
    - Visualizes the measurements/information.
    - Uses object-oriented programming.
    - Uses at least one design pattern.
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. Document the performance of your gripper
   E.g., perform 100 pick and place operations with the physical robot and document the grippers performance and any failures that might occur. An example use case that might help shape your thinking is attached at the end of the document.
6. Document the agile process you used

Nice additions could be:

- Visualization of the measurements / the gripper information in a GUI
- 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.

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
- ATMega644PA
    - https://www.microchip.com/wwwproducts/en/ATmega644PA (View datasheet button)
- ATMega32 migration guides
    - AVR505: Migration from ATmega16/32 to ATmega164P/324P/644(P)
        - https://www.microchip.com//wwwAppNotes/AppNotes.aspx?appnote=en592121
    - AVR527: Migrating from ATmega164P/324P/644P to ATmega164PA/324PA/644PA
        - https://www.microchip.com//wwwAppNotes/AppNotes.aspx?appnote=en591695
- AVR306: Using the AVR UART in C on tinyAVR and megaAVR devices
    - https://www.microchip.com/wwwAppNotes/AppNotes.aspx?appnote=en591470
- Generic UR tutorials:
    - https://www.universal-robots.com/academy/
- UR simulator:
    - https://www.universal-robots.com/download/software-cb-series/simulator-non-linux/offline-simulator-cb-series-non-linux-ursim-3143/ (for version 3.14.3, other versions available as well)
- 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.

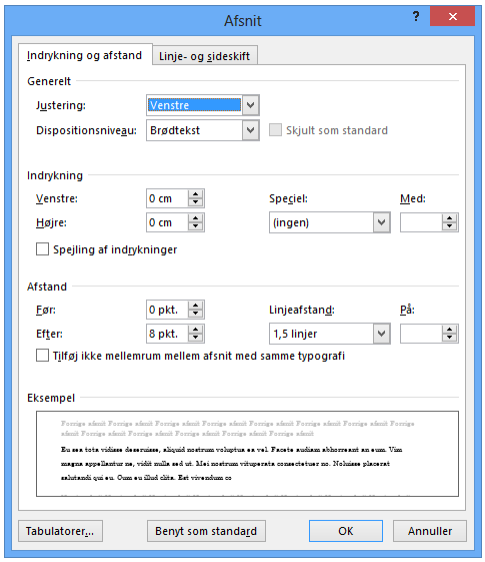
In case of an inactive group member, please follow this procedure:

- 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.



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.

Hand-in

Project must be handed in electronically on Digital Exam.

You are supposed to hand in one PDF with the report and a zip-file with C/C++ source code, Mathematica/MATLAB code, test documentation, supplemental material etc. In the report, there must be a list describing the contents of the zip-file. Please do NOT put the report in the zip-file. The report must be in a separate PDF file.

It is important that appendix, code, and material alike is put in a zip-file and the report is handed in as PDF since the report is automatically checked for plagiarism.

The report has a maximum size of 10MB. If the report is more than 10MB or handed in as part of the zip-file, the report will be treated as “NOT HANDED IN”.

The Zip-file with appendix and supplemental material can be more than 10MB.

Latest hand-in is Friday May 21st at 10:00. Please notice that the system automatically closes for hand-in.

Exam

The exam is a conversation between supervisor and student of approximately 20 minutes including grading. The supervisor and group agree on how the exam is executed in detail.

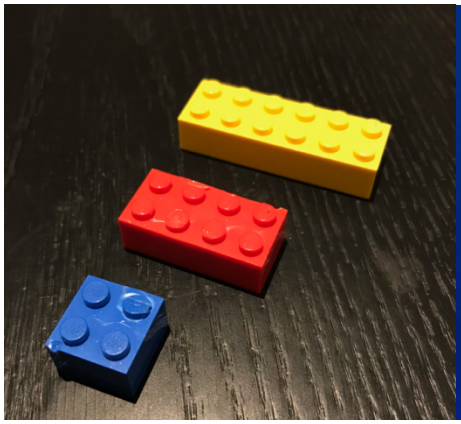
Example case: Packaging of Lego bricks!

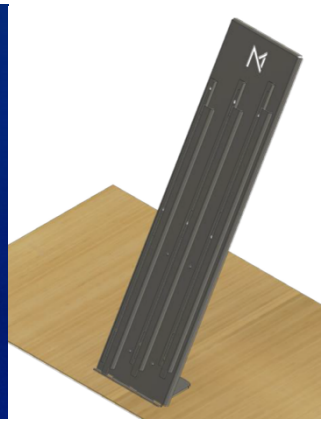
Note: This is just an example case, you are welcome to come up with another case and provide your own test elements.

A smaller toy 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 cobot 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.





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