COMP0246 Modelling and Motion Planning
Final coursework: Actuators, Mechanisms and Robot Dynamics

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To get full credit for the final lab, you are *required* to provide a .pdf report, a zip file containing your code for question 1 and a short text file explaining the contributions of each group member.

Kinematics, Jacobian and Path Planning

1. Please complete the coding tasks at:

   `https://github.com/surgical-vision/COMP0246_Labs/tree/main/final_lab`

   You can start with **git pull** in the **COMP0246Labs** directory. This should create a **final_lab** directory. Follow the instructions in the ReadMe (also via the above link), which contains further details. There are four tasks.

   Provide a very brief description of your progress on each part in the report.

   a. Implement forward kinematics, Jacobian and singularity detection for the KUKA YouBot. [Code - 5 pts]

   b. Use the Jacobian to calculate inverse kinematics and trajectories. [Code - 20 pts]

   c. Implement a ROS node that listens to your trajectory and publishes the transform to the end-effector, so the end-effector frame follows the trajectory. [Code - 5 pts]

d. Modify the target data file, adding more target points or changing the trajectory. Check that your program runs and behaves as it should. [Code - 5 pts]

Code 35 pts

Actuators and Mechanisms

2. A conveyor belt inside a candy factory carries colorful hard candy of quasi-spherical shape (e.g. Skittles, M&Ms, etc.). The candy is assumed to be stationary with respect to the conveyor, which moves at a constant velocity that cannot be altered. The conveyor belt is approximately 20cm wide and the candy appears randomly along its width. Assume the weight and shape of the candy are known. You are asked to implement a robotic system in addition to the conveyor belt to extract a candy of any given color and place it in a separate basket. The system should be able to perform the task as fast as possible. Ensure that you are designing a minimum viable system to solve the task and avoid, for example, redundancy in your manipulator design as well as your actuator and sensor choices. Propose a robotic system to perform the task. In your answer, address the following. (**Recommended answer is up to 50 words per sub-question.**)

   a. Required degrees of freedom of your manipulator in the Cartesian space of the end effector. [Report - 2 pts]

   b. Manipulator topology (serial/parallel) and design. You are free to reference commonly utilized designs and robot types. Also, state a reasonable choice of end-effector. [Report - 2 pts]

   c. Choice of actuators (e.g. stepper motors, AC motors, brushed or brushless DC motors, pneumatics, hydraulics, etc.) and transmission. This will vary greatly with your manipulator design. [Report - 2 pts]

   d. Choice of sensors (both, required for driving the manipulator as well as determining the correct object). [Report - 2 pts]

   e. Discuss a component of the proposed system (e.g. joints, actuators, sensors) which would be prone to wear from repeated task execution. How could the wear be minimized? [Report - 3 pts]

f. Assume, only candy with the previously specified color above a certain weight threshold (e.g. > 5 grams) should be placed in the basket. How could you modify your system to be able to consider this additional factor without modifying the conveyor? [Report - 4 pts]

[Report 15 pts]

Robot Dynamics

3. Describe the Huygens-Steiner theorem. Include a description of its hypothesis and of its derivation. Explain why it is important in robotics.

[Report 7 pts]

4. Define the forward and inverse dynamics problems, and highlight their main applications. Describe what are the difficulties of each problem.

[Report 8 pts]

Ethical and Environmental Considerations

5. Choose one of the robot applications areas listed in the taxonomy on Lecture 10 slide 16 (or pick another application area of your own):

   - Briefly describe up to four likely ethical and/or environmental factors that may arise for such a robot (positive and negative).
     [Report - 10 pts]
   - Describe possible strategies to alleviate any harm that may arise - to the user, the wider public or the environment.
     [Report - 10 pts]
   - Provide, with justification, your considered opinion of the likelihood that robots in this field will have a positive or negative impact.
     [Report - 15 pts]

   (Max 1000 words)

[Report - 35 pts]

END OF COURSEWORK