Project 1, INF4500

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Walking machines

The term walking machine is normally used in research fields where walking patterns (gaits) are developed, either for the study of gaits in its own, or for developing the physical structure or control system of legged robots. In the lecture notes various examples of walking machines are shown. In this project each group will design and develop its own legged walking machine, and the final machines will be demonstrated for an expert panel for approval and rewards. To simplify the project and focus more on the gaits, a rotating supporting central rod can be used to hold the balance of the robot.

- All submissions are uploaded by the students from the status page. Passwords are sent by email when the students are organized in a project group. For info on the group organization see this page.
- Submission requirements for each sub-projects are found in the upload page accessible from the status page.
- Project submissions for project 1a, 1b and 1c must be presented by the corresponding group members in plenum during this lecture dates (ca. 5 minutes for each group). During/after the presentation, feedback is given and a technical discussion may be initiated to enhance the collective learning process.

Project plan

The Ultimaker 3D printers on the ROBIN lab with PLA filaments are the primary printers to be used in this project. The cura software will be used to convert from SolidWorks STL files to G-code files for the printers. If you have special needs you can use other machines such as the Fortus 250C, Connex500 or the laser cutter (acrylic) in Sonen, but this must be approved by the teaching assistants first.

(A) In the first week we will start making the lower part (toe) of the robot. The main objective is to get a fast start on the work process and get used to CAD-NURBS modelling (SolidWorks) and 3D printing. In other words; the important part is to get up and going as fast as possible, and we will not pay much attention to whether the printed part (toe) will be used in the final robot or not. Redesign of the toe at a later point will be possible.

- Project 1a is based on individual work and delivery.

(B) A typical problem when developing a walking pattern for a legged walker is unpredictable friction between the toe and the floor. A plastic robot toe walking on carpet or linoleum will typically slip a lot, particularly if fast dynamic gaits are used. In this part we will therefore make a silicone sole for the toe. Both the Ultimaker and our Connex500 are able to print rubber-like materials but for various reasons this materials are inferior to real rubber or silicone. We will therefore use a 2 component liquid silicone and a casting mold made on the 3D printer. The final silicone sole can be designed for press-fit in matching holes between the sole and the toe or fastened by screws, or if large parts of the sole are inversely shaped to the toe it may just be stretched in place.

If support is used a typical challenge will be to ensure that all the support material is removable. For simple molds this can be done by proper orientation in the printer, but for more advanced molds, the mold must be split into several parts.

(C) In this sub-project each group will model the rest of the robot in SolidWorks by the use of the assembly feature. If complex organic parts are to be incorporated in the design, Blender (polygon subdivision) with PowerSurfacing can be used. Some of the parts must be matched to the Dynamixel actuators either by the use of the insert part feature in SolidWorks or by manually using a calliper by measuring the actuator geometry. When the robot assembly is finished, the walking pattern must be physically simulated with floor, gravity and actuators.

(D) In this part each group will print out the compete robot and make the physical assembly.

(E) In this part we start to implement the control system of the robot in Java/Processing. A single Dynamixel servo is first to be controlled.

(F) Finally we implement the complete control program for the robot and let it walk in front of an expert panel for approval.

Robot requirements

1. The robot must be "legged".
2. Actuators must be Dynamixel AX12/18, max 2 AX18 units and max 4 AX12 units. If available, more can be used, but this is not recommended. Optionally pneumatic cylinders or artificial muscle fibre can be used (require more work).
3. Max bus voltage 12V.
4. Robot must be free walking or connected to the central hub support system by the T-slot connector.
5. Dynamixel AX12/18 SolidWork files.
6. The height of the robot can be freely chosen (the central rod system height can be altered).
7. Max size of each printed parts: 200x100x100mm (parts can be joined by screws or glue).
8. Maximum total printed volume of robot/parts, including failed test prints for each group: 400cm^3.
9. If your part is very "common" remember to mark it with your group number (use the sketch text tool, and extrude cut) to avoid mixing it up with parts from other groups.

Design hints

If you have absolutely no clue how to start out designing the robot, it may help you structuring your thoughts if you try to adopt a theme to the design. A theme may be, for example:

- Making the robot a simple as possible
- Try to make the robot look alike something, a certain animal, a machine, or something else ...
- Try to make the robot walk as fast as possible. Then you have to think about what will be the limiting factors for speed
- Try to make the robot as small and compact as possible
- Try to make the robot walk as funny/stupid as possible. Unexpected moves, silly walks ...
- Try to make the robot walk as elegant as possible. Then you have to define elegant, ... can be "natural" moves, smooth sinusoidal moves ...

- Try to make the robot as artistic, or in other ways impressive as possible
- You may want the robot to give a certain impression, freeform/organic/natural or "machine like" (algebraic shapes)
- If you find some fascinating mechanisms or robotics parts on the web, try to implement them in the robot
- Just let the robot be as it turns out while you experiment with joints, with no overall aim. Just connect some links between servos and see if it walks ...

Just remember that none of these themes are better than others, they only help you structuring your thoughts. It feels better to know what you are doing when you do it. When you are in this starting phase of the design, browsing around the web looking at various pictures of robots, mechanical devices, animals, creatures, artworks, and every other things that may inspire you, may be interesting. When/if you watch a science fiction video with robots, try to pay attention to mechanical details.

In the starting phase of a design, you may find it helpful to make some initial rough sketches on paper

- Dynamixel configuration examples
- Robot/mechanical art and linkages

Have fun!