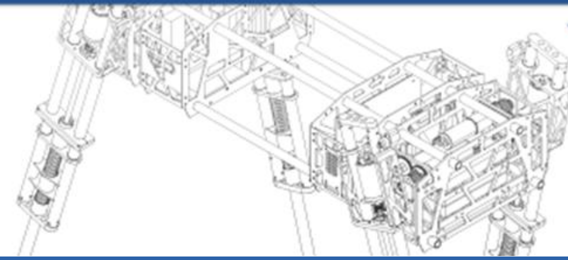
PROJECT PEGASUS



1st Newsletter of the Project Pegasus

INSIDE THIS ISSUE:

Special points of interest:

- What happened at the beginning of this year in Zürich?
- How was the start in Delft?
- How will the project proceed, in order to reach the goal?

The Project Pegasus

Project Pegasus aims to tackle a new challenge: create an autonomous robot capable of running for 10 kilometers in 10000 seconds; this implies relatively high speed, as well as high endurance and efficiency.

Running gaits are characterized by a lot of impact-losses. To counter these energy losses, Pegasus is designed with prismatic legs with integrated springs which allow impact energy to be stored and used again.

The design has been centered on the choice of motors to ensure a high power to mass ratio. The rest of the design is extremely light-weight to allow more batteries and therefore a higher energy to mass ratio. In order to be able to focus on an efficient control of running dynamics, the relatively simple environment of a running track is chosen.

Pegasus will thus have 3D freedom of movement but won't have to deal with sharp turns or obstacles and rough terrain. To quickly and effectively implement control for running in 3D, a good simulation environment is necessary and is being developed for Pegasus, in 2D and 3D, as well as state estimation with an extended Kalman Filter.

Finally, to enable autonomy in Pegasus, computer vision is being used for line extraction and position estimation.

Last weeks in Zürich

In January we finished the Design of our Robot in CAD and sent all drawings to Keller Laser and a workshop at the ETH Zürich. All parts were manufactured with highest precision and were sent perfectly on time!

We finally chose all electronic components and sent the orders, so that almost all components arrived before our departure.

After having finished the exams we started to assemble the robot. Since all parts were designed accurately, we were able to assemble the robot in one day without finding any conflicts.

In the same time we improved the simulation significantly and started the state estimation for the robot successfully. Having concluded everything in time we were able to depart satisfied to Delft.

Arrival in Delft

On the 15th of February we started to move to Delft. Especially the first group which brought the robot had some bureaucratic troubles at the border, but fortunately we were able to bring everything safely to Delft. The last group with all equipment of National Instruments arrived the 2nd of March.

At the TU Delft we were very lucky to receive two fully equipped offices, where we started to work as soon as we arrived.

Right at the beginning we started the intermediate report, which took most of the time.

After having finished it, we were able to put our whole effort into the project. We continued the assembly, where we attached all maxon motors into the leg and the leg module. Now we just have to wire all electronic components together.

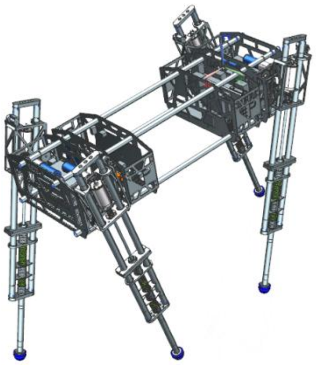
In parallel we practically finished the simulation, continued the programming of the vision and state estimation. Furthermore we started to program the control, the framework of the robot as well as the testing of all electronic components.

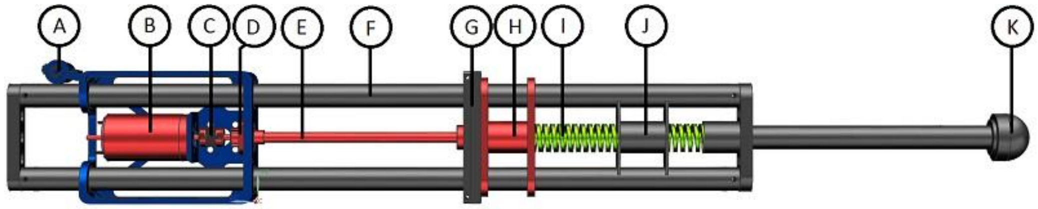
Project Pegasus:

“Running like Flying“

Structure of the leg

The Pegasus robot has a prismatic leg design with two degrees of freedom (Pic. 1). A spring (Pic. 1.I) can be used to store impact energy upon touchdown and release it again at take off. The resulting motion is a ‘pogo-stick’ like hopping with high efficiency due to the spring that stores the energy which is therefore not lost at ground collisions. The actuation in the telescopic direction is implemented with a motor (maxon motor) attached to a spindle drive (Pic. 1.E) that acts in series with the spring. It slides bars (Pic. 1.F) through sliding bearings to lengthen or shorten the leg. During the stance phase the leg is slightly extended to precompress the spring and thus put energy into the system to cover the friction and impact losses.





Leg design with encoder for the leg length (A), motor for linear actuation(B), coupling (C), ball screw bearing (D), ball screw (E), tubes for linear guidance (F), end stop with damping for the spring (G), ball screw nut (H), spring (I), buckling preventer (J), spherical foot (K). The hip part (blue) and the linear actuator (red) features 4 PTFE slide bearings and slide freely over the tubes (grey).

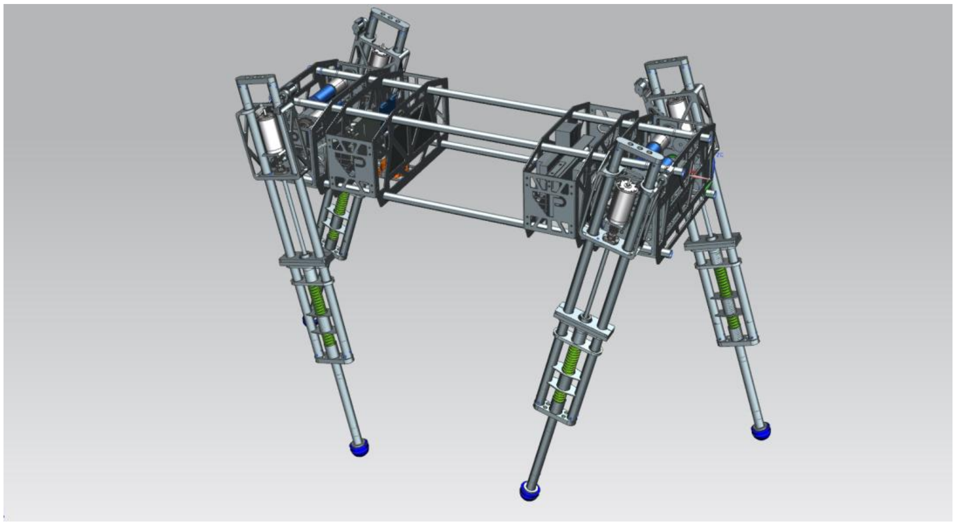
The Outlook

In the next few months we will focus our efforts in programming and testing the hardware as well as the whole robot.

The controller will be developed using the simulation which we will finish the next week. It relies on the concepts described by Marc Raibert in “Legged robots that balance”. The principle consists in treating hopping height, forward speed and body attitude as three separate control problems. It will receive the inputs from the state estimation, which uses all data from the sensors, in order to provide an estimate of its internal states, as leg length and acceleration. Furthermore we will continue to improve the vision, so that the robot will receive a robust signal of the running track.

In the same time we will also start to test initially one leg, then two legs and at the end the whole robot, in order to be capable to present the trotting Pegasus at the rollout. We made the choice not to start directly with the quadruped, with the intention to begin with an easier task, as one leg is, and learn step by step how to control the four legged Pegasus at the end.

Creating an autonomous running robot



Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich