Engineering Design Using a Small Autonomous Robot for Student Education

Overview

The importance of practical education for industrial engineering has recently begun receiving recognition in Japan as well as worldwide. Aichi University Technology (AUT) have been implementing many effective educational programs for students to acquire practical skills and knowledge. Among those, robot designing is one of the most effective for engineering design. Engineering design using small autonomous robots is useful for practical designing abilities. As a part of this activity, AUT participated in a demonstration test competition aiming for future Mars exploration - A Rocket Launch for International Student Satellites (ARLISS). More information on ARLISS can be found at http://www.unisec.jp/history/arliss.html.

Business Profile

Founded in 2000, AUT's concepts of education are to establish a comprehensive practical education for engineering design. As the baseline program for this basic concept, the activity of designing the autonomous robot is effective for the purpose of education. In 2017, an Internet of Things (IoT) special course for student engineers was created at the AUT University, as the IoT will be essential technology in robot design in the future.

In the design process the computer-aided tools (CAD, CAM, CAE) were applied, and Altair HyperWorks® was utilized for CAE, and OptiStruct® and MotionSolve® were used as CAE structural analysis tools to evaluate the stress in the robot's structure.

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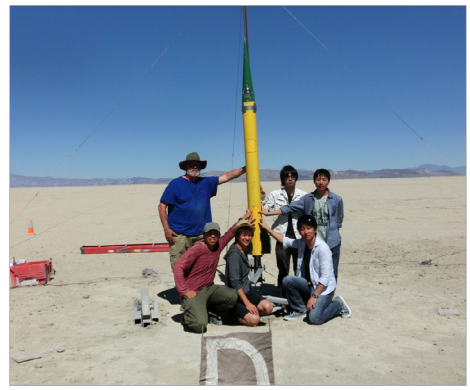
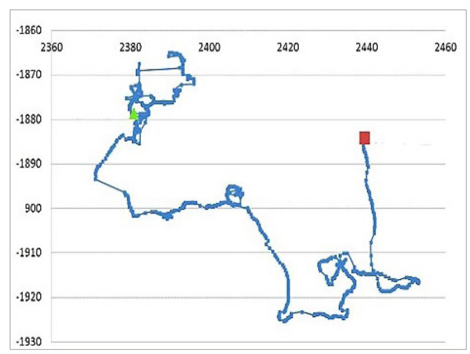


The AUT team getting ready to launch

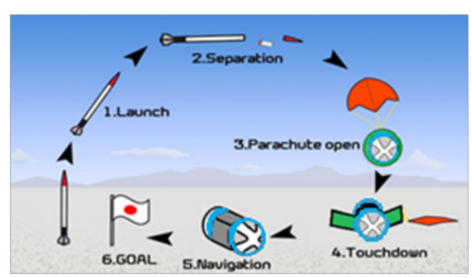
A Rocket Launch for International Student Satellites (ARLISS)

ARLISS is the demonstration competition event carried out to evaluate autonomous robots. The term of the convention is to separate a robot from about 4000m above the ground using a small rocket and descend freely by a parachute landing to the ground. The robot is to then autonomously travel to the exploration ground target. The purpose of this convention is to confirm whether autonomous traveling and investigation of the ground target can be carried out.

The figure on the right shows the actual running trace calculated from the log data taken from the running control data of the microcomputer embedded into the autonomous robot. The starting point in the figure represents the touchdown point of the robot dropped from a rocket. From the running trace chart onto the goal point in the figure, it is understood that the robot was running away searching its own location point and seeking goal point at the initial stage. After the robot detected its own location to the goal point, the robot was reaching the goal point gradually.



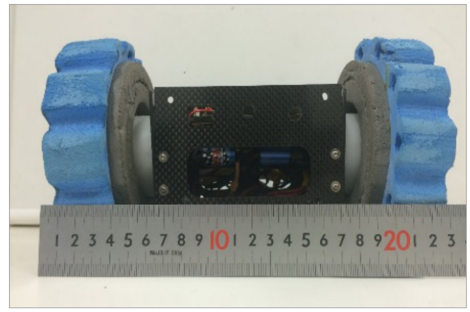
Robot's actual running trace calculated from the log data



Planned navigation sequence

An Optimal Design

The design process of an autonomous robot consists of several steps. An important step is the basic designing process based on a sketch drawing using sufficient imagination and taking the original idea. After the basic design was performed by sketches, the detailed design could be decided by concrete dimensions and 3D imaging using a CAD system. The prototype parts were manufactured using CAM and a 3D printer. After assembling the prototype, the practical design process was produced through extraction of the problem and creation of the improvement from evaluation tests.



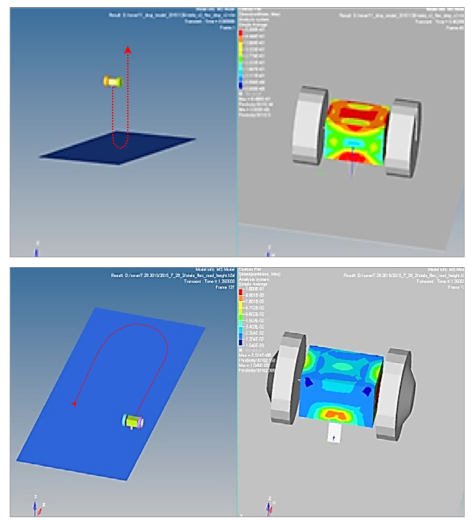
Size in mm of autonomous robot designed by the AUT team

The robot body was designed by “monocoque” structure of CFRP, and two wheels were made using the urethane sponge for the impact absorber. The material of the sponge wheels was selected by means of evaluation of the impact absorber at touchdown using an acceleration sensor.

The challenge was to design with optimal construction. The CAE was useful for the checking of assembled parts and combination balance of weight, structure size, body strength, etc.

For the final designed robot, HyperWorks was used for structural analysis to understand whether or not the robot meets the requirements. The evaluation was performed for the impact force received when launching a rocket, the impact when landing from the sky and the impact vibration from the road surface during running. MotionSolve in HyperWorks was extremely useful for practical industrial education that is linked to CAD design.

The internal stress during the robot’s movement however, is not so easy to analyze by theoretical calculation. Figures show an example of the internal stress distribution while the autonomous robot runs, and an example of it at the time the autonomous robot lands.



Internal stress distribution at landing and while moving on the ground

A Comprehensive Technology Design Education Method

The evaluation test showed no abnormality in the mechanical structure at the time of landing and running since the launch of the rocket and confirmed the demonstration of the structural analysis result. Through the fabrication of a small autonomous robot, AUT demonstrated the usefulness of a comprehensive technology design education method from both aspects of engineering method in structural design and electric circuit design in autonomous control design.

The autonomous robot has successfully reached its target location

Altair Engineering, Inc., World Headquarters: 1820 E. Big Beaver Rd., Troy, MI 48083-2031 USA
Phone: +1.248.614.2400 • Fax: +1.248.614.2411 • www.altair.com • info@altair.com