Constructing HUNVEYOR-4: the Educational Space Probe

György Hudoba, Zoltán Balogh, Attila Sáfár

Institute of Computer Engineering, Kandó Kálmán Faculty of Electrical Engineering, Budapest Tech
Budai út 45, H-8000 Székesfehérvár, Hungary
hudoba.gyorgy@szgti.bmf.hu, balogh.zoltan@szgti.bmf.hu, safar.attila@szgti.bmf.hu

Szaniszló Bérczi

Dept. G. Physics, Eötvös Loránd University
Pázmány Péter sétány 1/A, H-1117 Budapest, Hungary
bercziszani@ludens.elte.hu

Abstract: We report about the construction and main system characteristics of the fourth Hungarian University Surveyor at Székesfehérvár, Budapest Tech, Kandó Kálmán Faculty of Electrical Engineering Institute of Computer Engineering, Hungary

Keywords: HUNVEYOR, education, space, space probe

Figure 1
The first version of HUNVEYOR-4

1 Introduction

The name **HUNVEYOR** stands for **H**ungarian **UN**iversity Sur**VEYOR** The HUNVEYOR project – meaning university and college minimal space probe construction program – was initiated at the Eötvös Loránd University, Budapest in 1997 [1-3]. The Hunveyor-1 was built with camera and telescopic arm instrumentation. Later a rover was developed, with a test-field around it, its use was upgraded by an internet connection and a simulator. [4], [7-8] In time other Hunveyors were built with their own electronic and experiment constructions in different places and time in Hungary. The second one (Hunveyor-2) was built at the Pécs University, the third at the Berzsenyi College in Szombathely (Hunveyor-3). [5-6] The Budapest Tech Kandó Kálmán Faculty of Electrical Engineering, Institute of Computer Engineering (located in Székesfehérvár) joined to the project with Hunveyor-4 in 2001. Our realization is based also on individual solutions and we report the short story and recent state of the work [9-11].

2 Building HUNVEYOR-4

2.1 Aims

Our students will not become astronauts or geologists, of course. Yet the project is part of the “Space Education Program” through building different sensors, instruments, or even software in order to exercise engineering.

No one can seriously think that our HUNVEYOR space probe will fly in space. The primary aims of the HUNVEYOR project at our Institute are:

- forming an attractive, meaningful and long term framework for the research and development carried out by our students
- offering subjects for diploma and other project works
- obtaining skills in engineering, organization and realization of products
- get acquainted with the latest technology
- serve as reference in job hunting
- gain higher rank for our Institute

These goals have not changed over the years, but the HUNVEYOR-4 itself.

2.2 General System Overview

The HUNVEYOR-4 consists of

- mechanics
- scientific instruments, like sensors etc.
- on-board electronics
- computers
- software

The “landing unit” and the “rover” form the probe. Each one has some electronics and measuring instruments fixed on a mechanical frame. The probe can be reached through an internet connection from the “Terrestrial Control Room” which is a web portal running on the server of the Institute. This contains information about the project and acts as a bridge between the user and the probe.

The main parts with their interconnections are shown in Figure 2.

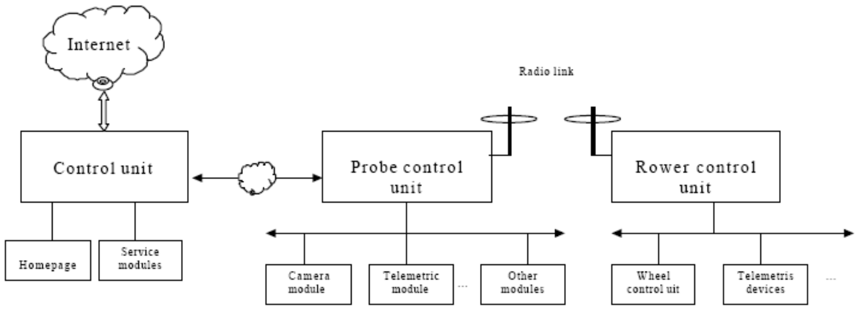


Figure 2
General overview

2.3 First Steps

The first step was to formulate and post the project, and to gain interest among the students. This was done by constructing and displaying the metal frame of the probe. After a while some students participated in the project by creating different instruments and software in order to control and organize the measurements. Because we wanted HUNVEYOR-4 to be open to the public, the students created a web-site as well, which mirrored the computer built in the probe (in case of the “road show”).

2.4 Main Parts of the HUNVEYOR-4

2.4.1 Frame

Our frame is a little bit smaller than the earlier Hunveyors. The frame is made of aluminum, with a square cross section of 20 × 20 mm in size (and a 2 mm thickness of the tube wall). Over the riveted clip support of the connections we used hardening plates and epoxy – glue for fastening. Some other cross section profiles (10 × 10 × 1 mm square and 20 × 3 mm ribbons) were also used in making the frame stronger. The result was a light-weight skeletal structure. The whole frame consists of about 100 pieces (without the rivets and the bolts). For further mounting holes (D=3,2 mm) were bored at every 40 mm distances in the frame bars (about 160 holes in total). There was a disadvantage to our solutions: we could not form "spatial" nodal points like the earlier constructions, therefore our tetrahedral frame form seems rigid as compared to the Surveyor, or the earlier Hunveyors [1].

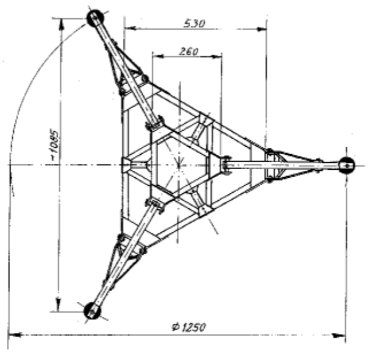


Figure 3
The frame of the Hunveyor-4

2.4.2 On-board Electronics

The electronics of the probe are based upon a PC motherboard and some special controller boards engineered by the students.

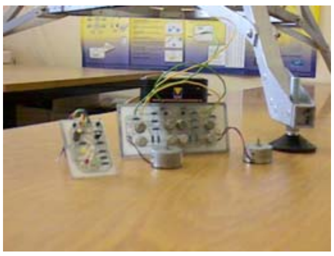


Figure 4
The spectrometer and the rower control board

The operating system of Hunveyor-4 is a Debian GNU/Linux 3.0 Woody system. We planned minimal energy consumption, therefore only the most necessary processes are run. The camera connects by an USB port to the computer. The direction and control of the camera movements are solved by the motherboard's parallel port. The image of the camera is stored in the server of the space probe.

This server also communicates with the web-server and sends the image from the web-camera to the server.

Figure 5
The electronics of the Hunveyor-4

2.4.3 Internet Connectivity

Our aim was to realize an electronic structure of the Hunveyor-4 experimental space probe, which can be directed and operated through the internet. We also intended to develop and enlarge the system.

The operation by a server was planned to run in the following way: before log-in the web-client user registers through an interface. All users get a process-number, (for parallel use). He or she can reserve an interval for his use of the Hunveyor-4 system. (For example 1 hour every day, for two weeks). Other users can reach the data, but not the modules for operation.

Connection between web server and the Hunveyor- 4: A connection is maintained between the probe and the web server by a flow of data through the channel. The web server sends the necessary parameters to the probe (i.e. camera angular position) and then the probe, after confirming the request sends the image and the other telemetric measurements.

The random connection failures (*the probe can not be reached)* are handled on the server. The future new modules need the modification of the program of the server although more servers may work parallel as well.

2.4.4 Rover

The rover extends the possibilities of the lander. The direction is controlled by a PIC microcontroller according to the routine of the central unit. The microprocessor works with a two-way communication between the central unit and the lander.

Motion: It has a four-wheel drive. The motors are DC motors and are controlled individually. This may be done over the internet as well.

Communication: The rover communicates using radio frequencies.

Energy support system: The rover has a 12 V, 7Ah capacity accumulator. This power is enough for short distance operations.

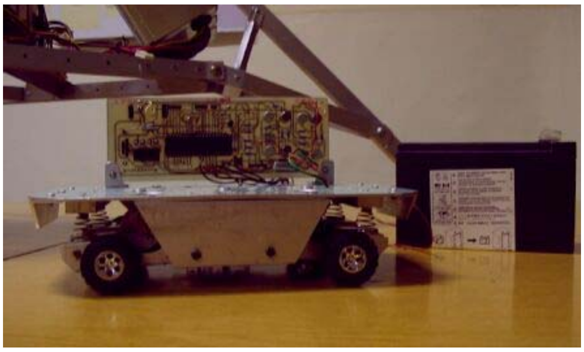


Figure 6

The rover with electronics

2.5 Scientific Instruments

2.5.1 Camera

We use a web-camera connected to the USB port of the motherboard for taking pictures of the surrounding environment. The stand can rotate the camera by 360 degrees by a stepper motor controlled via the parallel port. (Fig. 7) The user from her browser can set the picture quality (brightness and contrast) and the camera direction in 10 degrees steps.

2.5.2 Meteorological Station

The unit is cheap and reliable. It works in hostile environment to transmit data about the air temperature and the wind speed and its direction changes. Later on the capability of the unit can be extended by additional sensors (like pressure, humidity, etc), characterizing more precisely the environment of the probe.

Temperature: A current generator driven thermistor measures the temperature. The voltage fall through the thermistor is proportional with the temperature. This is measured by a microcontroller using a 10 bit A/D converter. Considering the non-linear characteristics, the digital data are transformed to temperature units in the central unit.

Wind speed and direction:

*Mechanics***:** The mechanical base, made of stainless steel, is sturdy enough to hold the wheel and weather cook (a composition of stainless steel and aluminum), and resist gusts of wind, humidity and acid rains. The bearing is very precise, originally used in a computer hard drive.

Sensors: After careful consideration the Balluff 516-325-S4-C inductive sensor was chosen, which is water, acid and shock resistant, and has a broad operational range (from –40C^o to +85C^o).

Electronic board: The electronics are based on a PIC 16A871 micro-controller, which picks up signals from the sensors. After some data processing it sends them to the main computer by RS-232. The data block sent to the PC consists of 3 bytes in the following order: #1 – temperature, #2 – speed, and #3 – direction value.

The wind-speed measurement: When the bar passes over the sensor, the sensor sends an impulse. The number of the impulses is counted in a register. Each complete turn makes three counts, up to 255. The microcontroller reads the value from the register in every 2 seconds (Fig. 8).

Determining the wind direction: The weather-cook consists of an oar, a vertical positioned aluminum sheet, a finger that moves over the sensors, a fine bearing and a series of sensors, all arranged in a circle (Fig. 9). The eight sensors mean eight directions and eight bits for the microcontroller as well. The size of the finger is big enough to be detected by two nearby sensors in middle position. The corresponding value, determined by the micro-controller is the sum of the two active bits. With this trick we have increased the angular resolution of the device by a factor of two.

Figure 7
The camera on its stand

Figure 8
Cup anemometer of Hunveyor-4

Figure 9
The weather-cook

2.5.3 Spectrometer

Using a spectrometer the composition of the soil can be calculated. In the measuring head four LEDs (with different wavelengths) are placed. They, one after the other, light the surface and the reflected light is measured by a phototransistor. We periodically switch the light sources on and off in the spectrometer in order to reduce the effect of the natural lighting. On the output of the phototransistor only the alternating component is analyzed. The output of the phototransistor connects to the input of an AD converter.

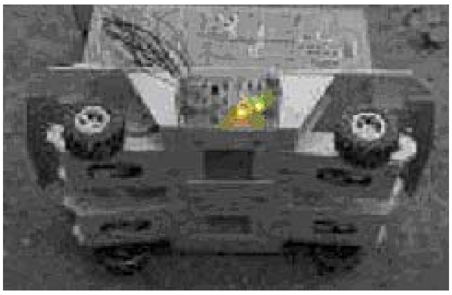


Figure 10

The spectrometer mounted on the side of the rover

2.5.4 Particle Radiation

We also placed an instrument on the rover in order to measure the background radiation. The impulses are conducted to the input of a microcontroller, which counts and summarizes them.

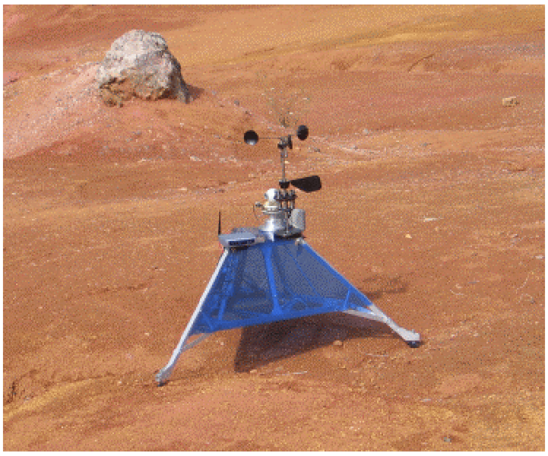
3 Upgrading HUNVEYOR-4

According to the changing time, the accumulated experience, findings and the user's claims we later redesigned the first version. The main goal was to free up the HUNVEYOR-4 from energy resources (e.g. mains and cables) in order to operating the probe on the field in real circumstances as well as making the probe more flexible and extendable.

3.1 Requirements of the Field Operation

- Low power dissipation (e.g. less energy demanding) motherboard
- Eliminating moving components like fans, hard drive, etc.
- Increasing transportability
- Single 12V battery/solar cell operation

- Wireless communication/remote control



Figures 11 and 12
The renewed HUNVEYOR-4 on the field

3.2 Requirements of the Extendibility

The first version of the HUNVEYOR-4 exhausted all its capability occupying all communicating (serial and parallel) ports. That means there is no room for new sensors or other devices (e.g. manipulators, etc.). Because we intend to expand the probe, we have to redesign the system hardware as well as the software.

According to the new concept,

- The sensors and devices are chained to an I^2C bus with a master device called Device Control Unit. This structure allows a virtually endless expansion of the system.
- The Device Control Unit communicates with the motherboard via USB.

- The Terrestrial Control interacts with the probe using the very promising XML-RPC protocol.

The work has just started.

The new concept gives numerous topics to our students.

Conclusions

The HUNVEYOR project has been successfully conducted for years. More and more popular, many students found it interesting and suitable to exercise engineering. The project is recognized by the NASA as well, accepting numerous publications. As a result, the project fulfilled its primary aims.

Acknowledgement

Thanks to my helpful colleagues and diligent students for all their support. The MÜI-TP-190/2003 fund is highly acknowledged.

References

[1] Sz. Bérczi, V. Cech, S. Hegyi, T. Borbola, T. Diósy, Z. Köllő, Sz. Tóth: Planetary geology education via construction of a planetary lander (1998), LPSC XXIX, #1267, LPI Houston

[2] Sz. Bérczi, B. Drommer, V. Cech, S. Hegyi, J. Herbert, Sz. Tóth, T. Diósy, F. Roskó, T. Borbola: New programs with the Hunveyor experimental planetary lander in the universities and high schools in Hungary (1999), LPSC XXX, #1332, LPI Houston

[3] Sz. Bérczi, S. Kabai, S. Hegyi, V. Cech, B. Drommer, T. Földi, A. Fröhlich, G. Gévay: TUTOR on the Moon: A Discovery type multiple lunar probe (improved Surveyors) constructing and research program for universities (1999), LPSC XXX, #1037, LPI Houston

[4] B. Drommer, G. Blénessy, G. Hanczár, K. Gránicz, T. Diósy, Sz. Tóth, E. Bodó: The 3D sytem and operations with Hunveyor (and its rover): WEB-site for students to use lander and instruments on a simulated planetary surface (1999), LPSC XXX, #1606, LPI Houston

[5] Hegyi S., Kovács B., Keresztesi M., Béres I., Gimesi L., Imrek Gy., Lengyel I., Herbert J.: Experiments on the planetary lander station and on its rover units of the Janus Pannonius University, Pécs, Hungary (2000), LPSC XXXI, #1103, LPI Houston

[6] Kovács Zs. I., Kõvári I. E., Balogh R., Varga V., Kovács T., Hegyi S., Bérczi Sz.: Planetary Science Education via Construction of the Hunveyor-3 Experimental Planetary Lander on Berzsenyi College, Szombathely, Hungary: Rock Radioactivity Measurements (2001), LPSC XXXII, #1130, LPI, Houston

[7] Bérczi Sz., Diósy T., Tóth Sz., Hegyi S., Imrek Gy., Kovács Zs., Cech V., Müller-Bodó E., Roskó F., Szentpétery L., Hudoba Gy.: Space Simulators in Space Science Education in Hungary (1.): A Hunveyor Type Planetary Voyage and Planetary Surface Operations Simulator (2002), LPSC XXXIII, #1496, LPI, Houston

[8] Sz. Bérczi, S. Hegyi, Zs. Kovács, E. Hudoba, A. Horváth, S. Kabai, A. Fabriczy, T. Földi: Space Simulators in Space Science Education in Hungary (2.): Hunveyor Orientations and Astronomical Observations on Martian Surface (2003), LPSC XXXIV, #1166, LPI, Houston

[9] Hudoba, Gy., Sasvári G., Kerese P., Kiss Sz., Bérczi Sz.: Hunveyor-4 Construction at Kandó Kálmán Engineering Faculty of Budapest Polytechnic, Székesfehérvár, Hungary (2003), LPSC XXXIV, #1543, LPI, Houston

[10] Gy. Hudoba, Zs. I. Kovács, A. Pintér, T. Földi, S. Hegyi, Sz. Tóth, F. Roskó, Sz. Bérczi: New experiments (in meteorology, aerosols, soil moisture and ice) on the new Hunveyor educational planetary landers of universities and colleges in Hungary (2004), LPSC XXXV, #1572, LPI, Houston

[11] T. Földi, H. Hargitai, S. Hegyi, Gy. Hudoba, Zs. Kovács, F. Roskó, Sz. Tóth, A. Pintér, Sz. Bérczi: Europa analog ice-splitting measurements and experiments with Ice-Hunveyor on the frozen Balaton-lake, Hungary (2005), LPSC XXXVI, #1147, LPI, Houston