The HUNVEYOR Project, an integrated science education program

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Abstract
The HUNVEYOR project is a long term experimental complex teaching program. It is currently running at several educational institutions ranging from high school to university level in Hungary. The project (engineering, constructing and using an exploration robot) integrates many fields of science. The HUNVEYOR-4 is an advanced student-made Surveyor-class environment monitoring, internet controllable robotic landing gadget with remote access, and suitable for "learning by experience" in many fields of physics.

1. Introduction

The 20th century gave a big boost for the technology and as a result our everyday life has been dramatically changed during the last 50 or 60 years. That was a great consequence of the cold war, especially of the "Space Race" announced by President Kennedy in September 1962 at Rice University with his famous words: "We choose to go to the Moon." Today we are living in the 21st century, in the so called "Space Age". Our lives are increasingly dependent on technology: from shopping, banking and smart phones to life-support devices, computers and the internet have gone from luxury items to being ubiquitous lifestyle accessories. Everybody expects this evolution to be sustainable with no obstacles to growth. The once young pioneers of the technical revolution are gradually retiring, and the knowledge and work must be passed on to the younger generation.
The reality is that interest in sciences and engineering is fading among the general population and also among the students. This is a world-wide phenomenon, and it is true to the Hungarian population as well. Our goal is to rekindle interest in careers in science and engineering. The HUNVEYOR project is our answer to this challenge.

2. The aims of the HUNVEYOR project

The primary aim of the HUNVEYOR project is to gain interest among young people of ages 15 to 21. We aim to make careers in science and engineering attractive by involving students in research projects and developments at their academic institutions. We provide them with personal experience by allowing them to become involved with masterminding, constructing and using advanced technological devices. We allow them to study real, complex situations outside "sterile" laboratory physics.

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3. History and motivation

The HUNVEYOR project is a long term experimental complex teaching program running at several institutions ranging from high school to university level in Hungary. The educational space probe building program was initiated in 1997 at the Roland Eötvös University (HUNVEYOR-1), and in course of time several other institutions joined the project. The name "HUNVEYOR" is an acronym for Hungarian UNiversity SurVEYOR. The "Surveyor" indicates that our template is the American built Surveyor-7 space probe that landed on the Moon in 1968. The surveying robot was fitted with a solar panel, an on board camera and several sensor devices. We believe that building a "space probe" in the Space Age is still an attractive project. Constructing, testing and using different sensors and devices (learning by personal experience) is an efficient way to teach physics. Let us assume, we are on the surface of Mars (or in any other location), and we want to know the local weather and numerous environmental parameters. We want to monitor these parameters in order to decide whether we humans would be able to establish a habitable space station in this environment. The measured data as well as the pictures can be retrieved on demand from the "Terrestrial Control Room" which can be reached from the web portal of the space probe:
http://hunveyor.arek.uni-obuda.hu

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4. HUNVEYOR-4 in physics education

HUNVEYOR-4 is an advanced student-made Surveyor-class environment monitoring robotic landing gadgets with remote access, engineered by the students of the Alba Regia University Centre, which is a campus of Óbuda University, located in Székesfehérvár. The solution (engineering, constructing and using an internet controllable exploration robot) integrates many fields of science including physics, electronics, robotics, computer and web programming and modelling. It involves creating space-inspired animations, conducting planetary analog field studies and conducting various experiments. These experiments include monitoring the environment by measuring temperature, wind speed and direction, detecting soil pH, collecting magnetic dust (the so called "magnetic mat" experiment), and so on. With guidance by the teachers, the great bulk of the project is being done by the students of age 18 to 21.

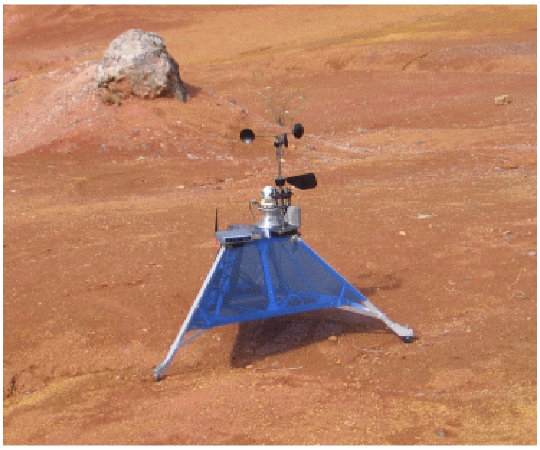

Figure 1. HUNVEYOR-4 during a Martian analog terrestial field study

In the following below we go through some of the building elements of HUNVEYOR-4, pointing out some opportunities to discuss physics.

Building element:

Figure 2. The frame of HUNVEYOR-4

Topics to discuss: force as vector, adding and subtracting vectors/forces, standing stability, pressure, vibrations, different macroscopic properties of matter, strength, stress, elasticity, thermal expansion

Building element:

Figure 3. The weather station

Topics to discuss: temperature and its measurement, temperature scales, air pressure and its dependency on sea level, Pascal's principle, vacuum, air flow, laminar and turbulent flow, electric discharges, lightning and detecting electromagnetic waves

Building element:

Figure 4. The webcamera

Topics to discuss: various kinds of optics, light as ray and as wave, optical imaging and different aberrations, light and matter interaction, quantum properties of the light, detecting light, principles of the CCD

Building element:

Figure 5. The student made LED spectrometer

Topics to discuss: the complete electromagnetic spectrum, spectral properties of the matter, emission and absorption, semiconductor physics: energy bands, electrons and holes, electron-hole recombination, the PN junction, LEDs and LDs

Building element:

Figure 6. The personal radiation detector

Topics to discuss: particle radiation, radioactivity, stability and decay of elements, nuclear energy and power plants, elementary particles, cosmic rays, radioactive dating methods (like C14 dating), health issues

These are just a few examples of the numerous opportunities for teaching physics in the HUNVEYOR project. In addition to the device-specific topics there are other important fields to discuss. For example, what are the requirements for operating the space probe on a remote field, far from electric network? How would the space probe perform in space, i.e. in vacuum, where no air cooling is possible? These questions lead to discussions regarding energy and energy budget, determining the energy requirement of individual parts and of the complete device and establishing power sources, batteries and solar panels. Additional topics are heat dissipation, transportability and vibrations, radio communication, remote control and robotics. While using the device and taking measurements we can discuss the different kinds of errors, the statistical properties of the measurements and the importance of error estimation.

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5. Using the educational space probe

To provide an example, we review a planetary analog study. In this experiment we capture magnetic dust particles on a slope. The first step is the calibration process, taking place in the laboratory, using different soil composition and slopes. The second step is taking actual measurements in the field. Comparing the results with the laboratory records allows students to infer the magnetic content of the soil gathered in the field. The Viking and the Mars Pathfinder space probes found magnetic materials while studying Martian dust, providing the motivation for this experiment. The tasks are simple enough to be carried out by students, however, the various components of the experiment make it more complex. The comparison to the natural environment provides an experience usually missed in “clean laboratory procedures”, providing exposure to the complexity of environmental measurements. Physical properties to be studied are as follows:

- Sticking magnetic material on a slope
- Blowing away particles by the wind
- Changes in sticking behaviour by changing mixture composition

Step one: calibration in the laboratory.

We constructed a magnetic mat from refrigerator magnets (magnetic strength about 5 mT) covered by a white sheet of paper. We prepared different mixtures of sand, ferromagnetic materials and gypsum. We aligned the slope and spread the mixture onto the top of the slope. The magnets captured part of the ferromagnetic dust and formed a pattern. We repeated the experiment with different compositions and recorded the results.

The materials we used for the mixtures included sand (fine grained and coarse grained), rust (fine grained and coarse grained), iron (fine grained and coarse grained) and gypsum ($CaSo_4$). From the calibration process we found that the minimal slope for sliding was 32,5 degrees for the coarse grained and 36 degrees for the fine grained mixtures. Using this result we decided to use a 45 degree slope.

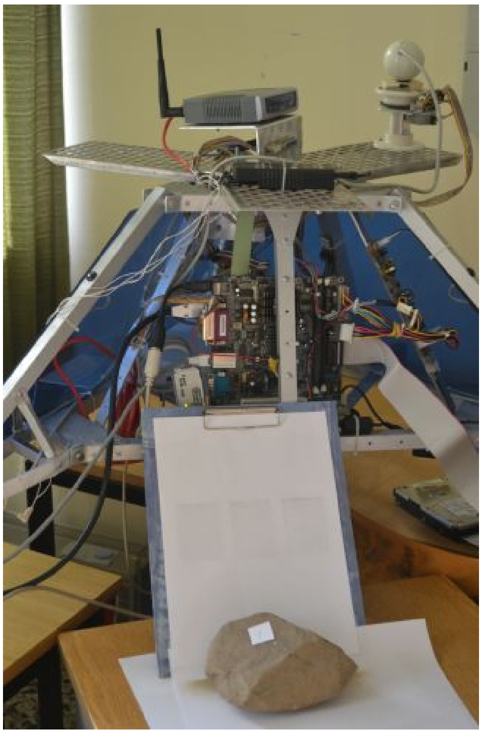

Figure 7. Using HUNVEYOR-4 during the calibration process

For the friction coefficients we obtained μ=0.54 for the coarse grained mixture and μ=0.59 for fine grained mixture. We also calculated the sliding speeds at the top and at the bottom of the magnets. We found the numerical values of 1.3 m/s and 1.8 m/s for the coarse grained and 1.1 m/s and 1.6 m/s for the fine grained mixtures. All values refer to the slope aligned to 45 degrees.

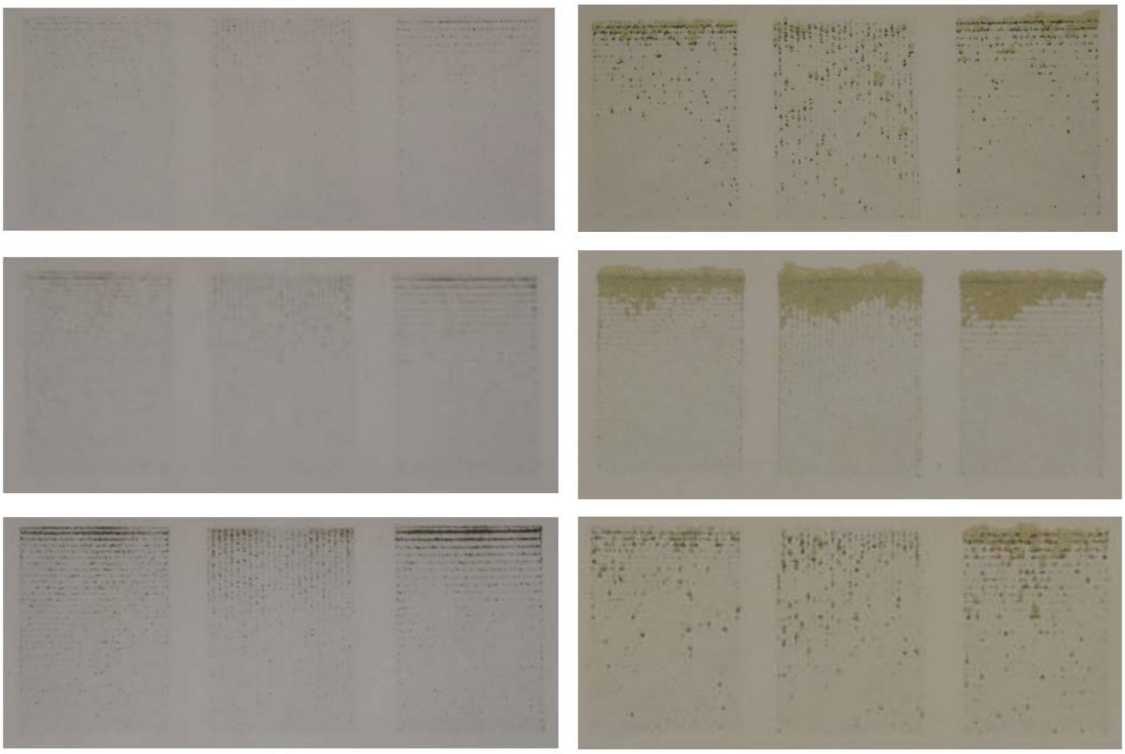

Figure 8. left: fine grain two component, right: coarse grain three component patterns

Step two: field study

We relocated the space probe to a Martian analog field some 20 km from our city and applied soil to the magnetic mat. Then, we took pictures with the webcamera of HUNVEYOR-4 as can be seen in figure 9.

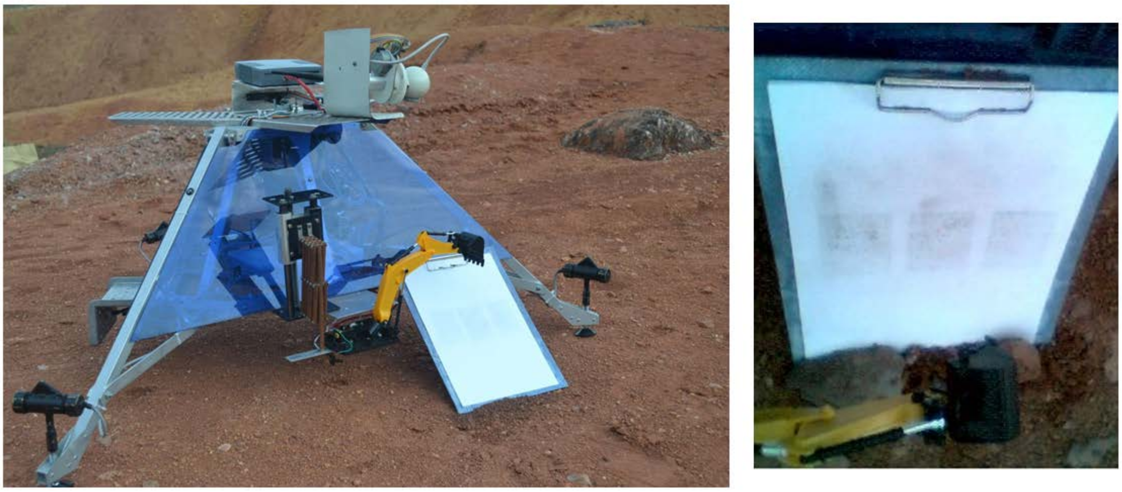

Figure 9. The Martian analogue terrestial field experiment

Comparing the results to the calibration records we concluded that the ferromagnetic component of the soil is nearly 5%

6. Conclusions

The HUNVEYOR project has been successfully conducted in Hungary for more than ten years. The project forms an attractive background for meaningful, long term research, experiment and development and gives a wide variety of topics for studying physics. As a byproduct, students develop a lasting relationship with their teachers, furthering their career aspirations and options in science and engineering.

Acknowledgements

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