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at Budapest University of Technology and Economics

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Faculty of Electrical Engineering and Informatics
Budapest University of Technology and Economics
and
Hungarian Astronautical Society

Editors
László Bacsárdi and Kálmán Kovács

MANT 2022

Conference proceedings

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WELCOME from the Organizing Committee

Welcome to the 7th edition of our H-SPACE conference series!

We are happy to welcome you at the 7th International Conference on Research, Technology and Education of Space. Special welcome to those participants who join the H-SPACE conference for the first time.
The event is organized by the Faculty of Electrical Engineering and Informatics at the Budapest University of Technology and Economics (BME) – in cooperation with the Hungarian Astronautical Society (MANT), which is the oldest space association in Hungary. The organization of the conference series started in 2015, at a time of growing opportunities arising from ESA recently granting membership to Hungary and the need for a joint presentation of space activities pursued at BME. The selection of the date of the event pays tribute to the successful deployment to orbit and mission of the first Hungarian satellite, the Masat-1, which has been launched on February 13, 2012.
In last August, the Hungarian government accepted our national space strategy which is available on the website of the Department for Space Activities of the Hungarian Ministry of Foreign Affairs and Trade at space.kormany.hu. In October, our national astronaut program – the Hungarian in Orbit (HUNOR) – has been announced: Hungary plans to send an astronaut to space in 2024 with Axiom Space. The recently published Hungarian Space Kaleidoscope 2021/2022 contains more than 60 companies, research institutions and university departments working in the Hungarian space sector. In September 2022, Budapest University of Technology and Economics will start the first class of its space engineering MSc curriculum. In parallel to this, the Ministry of Foreign Affairs and Trade coordinates a nationwide postgraduate education program in four different domains including engineering.
The topic of this year's conference is "New trends in the space sector". The agenda of the conference addresses scientific, technological and educational issues of space research and space activities. The conference is open for both local and international professionals and provides an opportunity to showcase Hungarian scientific, technological, educational and outreach activities, related to space.
The Organizing Committee has internationally recognized members: Prof. József Ádám, Dr. Balázs Bartóki-Gönczy, Dr. Tibor Bálint, Ferenc Horvai, Prof. János Lichtenberger, Dr. Lóránt Földváry, Prof. László Pap, Dr. Andrea Pődör, Prof. Gábor Stépán, Dr. Szabolcs Rózsa. We are grateful for their contributions to the success of the conference.

On the first day, we will host in person presentations which will be live streamed for online participants. The second day we will host online presentations. The conference will have four main sections: a Plenary with invited presentations. Session Science and Technology I-II and Session Education and Outreach.

This year's invited presentations will be the following:

- *"Space ecosystem building: case study Slovakia"*, by Michal Brichta, Head of Industrial Branch of the Slovak Space Office
- *"The effects of the war on the global space policy"* by Balázs Bartóki-Gönczy, Head of Outer Space and Social Sciences Research Center University of Public Services, Hungary.
- *"HUNOR Hungarian Astronaut Program Briefing"* by Balázs Zábori, HUNOR program manager, Centre for Energy Research, Hungary
- *Nationwide cooperation in space education – The UniSpace Hungary Consortium*, by Bianka Parragh, Programme Director, Head of Space Economy and National Competitiveness Research Group, University of Public Services
- *"Space Engineering Curriculum at the Budapest University of Technology and Economics"*, by László Csurgai-Horváth and László Bacsárdi, BME

This book contains the abstracts of the presentations. In the coming months, selected full papers will be published in the official conference proceedings which will be available on our website, space.bme.hu. On this website, the proceedings and selected papers of the previous issues can be found as well.
We hope you will enjoy your time in Budapest and the H-SPACE conference could help to learn about new scientific and technological results and strengthen your network. We hope to welcome you again at the next edition of H-SPACE, at the H-SPACE 2024, which will be organized in February, 2024.

László Bacsárdi
co-chair
Vice President of MANT

Kálmán Kovács
co-chair
President of MANT

PROGRAM

April 7-8, Budapest, Hungary
space.bme.hu

April 7, Thursday

Location:Building I, ground floor, IE.007
Budapest University of Technology and Economics
Magyar tudósok krt. 2., Budapest, H-1117

The first day will be live streamed for online participants.

Session Chair: László Bacsárdi

14:00 Opening ceremony
Orsolya Ferencz, Ministerial Commissioner, Ministry of Foreign Affairs and Trade
Hassan Charaf, Dean, Faculty of Electrical Engineering and Informatics, BME
Kálmán Kovács, President, Hungarian Astronautical Society

14:15 Invited presentation
The effects of the war on the global space policy
Balázs Bartóki-Gönczy, Head of Outer Space and Social Sciences Research Center University of Public Services, Hungary

14:40 Invited presentation
HUNOR Hungarian Astronaut Program Briefing
Balázs Zábori, HUNOR program manager, *Centre for Energy Research, Hungary*

15:05 Invited presentation
Space ecosystem building: case study Slovakia
Michal Brichta, Head of Industrial Branch of the Slovak Space Office

15:30 Coffee break

Session Chair: Kálmán Kovács

16:00-18:00: Technical presentations – Session Science and Technology I

Experiments on MRC-100 PocketQube
Tibor Herman and Levente Dudás

QO-100 video signal transmitting
Anna Gertrúd Fábián and Róbert Varga

Miniaturized and modular flow chemical reactor for space applications
Ferenc Darvas, Ferenc Boncz, János Takács and Gergő Mezőhegyi

GNSS interference events at Hungarian airports
Bence Takács, Daniel Garcia, Mercedes Reche and Rita Somogyi

Nationwide Ground Motion Map of Hungary Based on Sentinel-1 PSI Data
Péter Farkas, Gyula Grenerczy and Sándor Frey

The Jovian Plasma Dynamics and Composition Analyzer (JDC) – a sensor of the Particle Environmental Package (PEP)
Máté Kerényi, Philipp Wittmann and Martin Wieser

Radio astrometric support for the JUICE mission to Jupiter
Sándor Frey, Judit Fogasy, Krisztina Perger, Krisztina Gabányi and Janka Kőmíves

Hungarian Participation in JUICE Mission of ESA
János Nagy, László Hevesi, Pál Gábor Vizi, Lajos Szalai, István Horváth and Sándor Szalai

April 8, Friday

Location: online
Registered participants will receive the link for online participation.

Session Chair: László Pap

10:00—12:15: Technical presentations – Session Science and Technology II

Rain Field Sensing Supported by GPS Signal Attenuation
László Csurgai-Horváth, János Bitó, Péter Horváth,
Bálint Péter Horváth and Árpád László Makara

Application of Artificial Intelligence in Satellite Communications
Árpád László Makara and László Csurgai-Horváth

Limits of ion-trajectory controll using electric field
András Reichardt, Árpád Makara and László Csurgai-Horváth

A wide-band spectrum monitoring system as a scientific payload for MRC-100 3-PQ(Pocket Qube) student satellite
Yasir Humad and Levente Dudás

InSAR monitoring results of Transcarpathia in the GeoSES Project
Bálint Magyar and Roland Horváth

Using quantum algorithms for Earth Observation data processing
Doaa Subhi and László Bacsárdi

Topic discovery in the diaries of Antarctica winteroverers with multilingual deep sentence encoders
Márton Makrai, Bea Ehmann and László Balázs

Distant Psychological Monitoring of ICE-Groups: Quantitative and Qualitative Content Analysis Approaches
Bea Ehmann, Anna Altbäcker, Borbala Tölgyesi
and László Balázs

Investigating Cognitive Changes in Space Analog Paradigms
Borbála Tölgyesi, Anna Altbäcker, Irén Barkaszi, Bea Ehmann
and László Balázs

12:15 - 13:15 Lunch break

Session Chair: Sándor Frey

13:15—15:15: Session Education and Outreach II

Invited presentation

Nationwide cooperation in space education – The UniSpace Hungary Consortium
Bianka Parragh, Programme Director, Head of Space Economy and National Competitiveness Research Group, University of Public Services

Invited presentation

Space Engineering Curriculum at the Budapest University of Technology and Economics
László Csurgai-Horváth and László Bacsárdi, BME

IRF SpaceLab – a Swedish example of opening research infrastructure for external users
Máté Kerényi and Stas Barabash

Székely Mikó T3Ki-rover
Mária Pető

Flórián Vámosi and László Vámosi
Astronomy activities at the Mihály Táncsics Grammar School of Kaposvár

How Tech Companies can help to Teach Space
Flórián Vámosi, Miksa Vámosi and Andrew Yake

Simulated Mars Rover Model Competition – Years of Pandemic Challenge
Pál Gábor Vizi and Attila Sipos

15:00 Closing remarks

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ABSTRACTS

A wide-band spectrum monitoring system as a scientific payload for MRC-100 3-P (Pocket Qube) student satellite

Yasir Ahmed Idris Humad*, Levente Dudás
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Today, the development of student satellites, which are classified as nano-satellites, is becoming increasingly common in a variety of applications. Student satellites came as an excellent alternative for huge satellites in numerous applications and space exploration, which is due to their small sizes and low costs as well as the short time period needed for their manufacturing. Unlike the traditional space missions, nano-satellites rely on commercial off-the-shelf (COTS) components to decrease costs and speed up development. Generally, the nano-satellite term designates satellites in the 1 – 10 kg mass range. However, the modern proposed class is the Pocket Qube Satellite which restricts developers to a volume of approximately 5 x 5 x 5 cm for 1 unit and 0.1 – 1 kg mass range. Many Pocket Qube Satellite experiments can be found in the Microwave Remote Sensing Laboratory at the Department of Broadband Infocommunications and Electromagnetic Theory at BME.
The main aim of this paper is to present the capability of designing 3-PQ (Pocket Qube) student satellites for scientific payloads with limited size, weight, and power consumption. The planned scientific payload of MRC-100 is a wide-band spectrum monitoring system(30 – 2600) MHz This system is able to measure the upper HF and, VHF band, UHF band,5G band, 4G band, GSM band, and UMTS band at the laboratory environment as a prototype (first phase). The realized prototype panel of the spectrum monitoring system is now working, is able to measure RSSI (Received Signal Strength Indicator) values on three different RF bands, it can be used as a conventional scalar spectrum analyzer with less than 120 mA current consumption from 3.3 V nominal regulated bus voltage and 40x40 mm PCB (Printed Circuit Board) size.

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* corresponding author

Keywords:
Student Satellite, PocketQube, Radio Frequency Smog, Spectrum Monitoring System.

References:
[1] Takács, Donát; Markotics, Boldizsár; Dudás, Levente; Processing and Visualizing the Low Earth Orbit Radio Frequency Spectrum Measurement Results From the SMOG Satellite Project
[2] Dudás, Levente ; Gschwindt, András; Filling the Gap in the ESA Space Technology Education
[3] Dudás, Levente ; Gschwindt, András; The Communication and Spectrum Monitoring System of Smog-1 PocketQube Class Satellite

Application of Artificial Intelligence in Satellite Communications

Árpád László Makara*, László Csurgai-Horváth
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In connection with satellite-Earth communications the changes in the atmosphere affect the quality of the radio link. For the reliable and uninterrupted data transmission the alternating of the modulation and, in many cases, the coding is advantageous. In real-time, these methods are called Adaptive Coding and Modulation Methods (ACM). The most straightforward strategy is to change the coding or modulation if we find that the amount or quality of the transmitted data is inadequate. This means that there may be periods when due to the channel impairments the maximum capacity of the transmission channel can not be achieved.

The solution to this problem is to predict at least some of the typical transfer quantities. The available solutions are usually regression problems [1,2,3], relying on artificial intelligence to estimate either signal-to-noise ratio or attenuation. There are differences in each technology and the algorithms used, but almost all of them are based on a training method using formal measurements.

In our previous work, we presented a procedure, that performs a new classification method. We do not predict a specific signal-to-noise ratio or attenuation, or the best expected modulation or coding.

Our method works acceptably for two-state forecasting [4], namely the state of fade/non fade. Predictions implemented in this way are expected to perform similarly well with fewer resource requirements than before.

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In this paper, we present a brief overview of the possible solutions and we perform a comparison of the different solutions. The base of the comparison is the conditions of the training of the AI used, its reusability and the possibilities of applying the predicted output.

Keywords:
artificial intelligence, satellite communication, deep learning, prediction, ACM

References:
[1] J. Ebert, W. Bailer, J. Flavio, K. Plimon and M. Winter, "A Method for ACM on Q/V-Band Satellite
Links Based on Artificial Intelligence," 2020 10th Advanced Satellite Multimedia Systems Conference
and the 16th Signal Processing for Space Communications Workshop (ASMS/SPSC), 2020, pp. 1-5, DOI: 10.1109/ASMS/SPSC48805.2020.9268889.
[2] L. Bai, C. -X. Wang, Q. Xu, S. Ventouras and G. Goussetis, "Prediction of Channel Excess Attenuation for Satellite Communication Systems at Q-Band Using Artificial Neural Network," in IEEE Antennas and Wireless Propagation Letters, vol. 18, no. 11, pp. 2235-2239, Nov. 2019, DOI: 10.1109/LAWP.2019.2932904.
[3] Yongxian Yu and Luyong Zhang, "Adaptive Modulation Scheme for Satellite Communication Channel Based on RLNN," Journal of Physics: Conference Series 1856, no. 1 (April 1, 2021): 012053, accessed December 15, 2021, https://iopscience.iop.org/article/10.1088/1742-6596/1856/1/012053.
[4] Árpád László Makara, Tamás Deli és László Csurgai-Horváth, "AI-Supported Fading Prediction", 26th Ka Band Communications Conference, Washington DC, 2021, Propagation 4, ISSN-2573-6124.

Astronomy activities at the Mihály Táncsics Grammar School of Kaposvár

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As a High School with specialized scientific classes, we think it's very important, to have some after- school activities with the topic of Astronomy and Space. High School is most probably the latest stage that students can be guided towards STEM. Our school has been building these activities from 2016.
We have participated in all of the European Astro Pi Missions, with great success. We organize events for the interested students to look into telescopes and take our telescopes to the meets and star parties of the Vega Astronomical Association. We also regularly launch High Altitude Balloon experiments.
In the past years Astro Pi missions our students have detected the weakest points of the Earth's magnetic field, imaged lake Balaton from space, proved the Earth's shape is globular and detected signs of civilization from the International Space Station. More than 300 students (and adults for that matter) look through our telescopes every year. We usually show them the Moon, planets and some brighter Deep-sky objects. During the star parties of the Vega Association, we usually have our biggest telescope out, a 16" Dobsonian and observe very faint objects as well, with the most advanced students. As well as observing, we also teach the astrophysics part to the most interested students. Thanks to this since 2016 we always had a student in the IOAA Hungarian national finals.
Our Weather Balloons are also usually launched from the Vega summer star parties. During these experiments, we have recorded data of the radiation in the stratosphere, imaged some of the planets and the moon, collected follow-up data for the magnetic field experiments with the Astro Pis and brought the "first Hungarian Near-Space Telescope" (a not remotely, but operational instrument) to around 25 kilometers in altitude. Our most successful 2021 experiment reached more than 36 kilometers in altitude.

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* corresponding author

The biggest project we've undertaken yet in this field is just around the corner, however. The school has successfully received funding to acquire a mobile planetarium with the capacity of around 20 students per lecture. This will be the only planetarium in town, thus making these kinds of lectures available to more students in Kaposvár, than ever before.

Keywords:
Astronomy, education, High-Altitude Balloons, Astro Pi, planetarium

References:
[1] Astro Pi Website, http://astro-pi.org
[2] UltimaSpace Website, http://ultima.space/2019experiment
[2] Vega Astronomical Association, http://vcse.hu
[3] Our 2020 balloon launch, https://www.youtube.com/watch?v=B8mZT2IEh7o&list=PLqDRpAl4U-vx1HXYRswAhlzylyRGpQvI1

Distant Psychological Monitoring of ICE-Groups: Quantitative and Qualitative Content Analysis Approaches

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Wherever mankind goes to explore outer space (orbital missions, future Moon and Mars settlements), crews are and will always be isolated and confined groups, encapsulated in extreme environments (ICE Groups). In the present state of the art of space psychology, terrestrial space analogs are accepted as valid sources of investigation. There are two types of such facilities: space analog environments (e. g. Antarctic winterovering stations) and space analog simulations (e. g. Mars-500 and Sirius projects in Moscow). Distant monitoring of ICE-Group psychodynamics in these facilities is important because this forms the base of psychological countermeasures for future manned space missions.

Psychological states and processes of ICE groups are traditionally monitored by tests and questionnaires, and in recent years by content analysis. Content analysis is reasonable for use in psychological research because a great variety of linguistic markers, detectable in verbal behavior (diaries, correspondence, online communication, etc.), may allow for drawing consequences as to the psychological states and processes of individuals and groups. The software-based psychological content analysis permits seeing “deep into the text”, where we can detect patterns imperceptible to the naked eye (Ehmann, 2002).

Our research group has been using psychological content analysis methodology in several international terrestrial space analogs for more than a decade. Our presentation discusses the main approaches to the field and demonstrates some of our results in this context. One traditional approach is a thematic content analysis where space psychologists compared crew diaries written by crews in terrestrial analogs and the International Space

* corresponding author

Station (Stuster, 2010). Another traditional approach is psychological construct-based analysis, for example, the investigation of coping mechanisms (Suedfeld, Brcic & Legkaia, 2009). Word frequency-based analysis was used in our analysis of video diaries of Antarctic winteroverers in cooperation with ESA (Ehmann, et al, 2018). Corpus linguistic-based analysis was made in the Mars-500 terrestrial simulation in cooperation with the Institute for Biomedical Problems where, among others, changes in crew autonomy and time consciousness were studied (Gushin, et al., 2012).
More recently, we have also performed a qualitative content analysis on the Antarctic winteroverers sample to explore emotional time patterns and cultural differences between Concordia and Halley crewmembers. The swift progress of Natural Language Processing (NLP) methodology promises ever more elaborated and automatized, objective, non-invasive, and standardized insight into the psychodynamics of ICE-groups whether down here on Earth or onboard a spaceship.

Keywords:
Terrestrial space analogs, ICE-groups, distant psychological monitoring, content analysis

References:
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Ehmann, B., Altbäcker, A., & Balázs, L. (2018). Emotionality in isolated, confined, and extreme (ICE)
environments: Content analysis of diaries of Antarctic Winteroverers, Journal of Environmental
Psychology, Volume 60, December 2018, Pages 112-115
Gushin, V., Shved, D., Vinokhodova, A., Vasylieva, G., Nitchiporuk, I., Ehmann B, & Balazs, L. (2012).
Some psychophysiological and behavioral aspects of adaptation to simulated autonomous mission to
Mars. Acta Astronautica, January–February 2012, Pages 52–57
Stuster, J. (2010). Behavioral issues associated with long-duration space expeditions: review and
analysis of astronaut journals: experiment 01-E104 (Journals). Houston, TX: National Aeronautics and
Space Administration, Johnson Space Center.

Experiments on MRC-100 PocketQube

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MRC-100 is the upcoming PocketQube mission of BME (TU Budapest), with new and extended measurements and experiments led by the same András Gschwindt who was the project manager of the previous satellites of BME. The 3PQ (5x5x15cm) satellite will provide opportunity to several other universities to carry out measurements with their equipment in space alongside our own ones. The primary mission will be a wide range electrosmog measurement from 30 MHz to 2.6G Hz, with just one measurement antenna as a challenge. In order to transmit the large amount of data gathered from the measurements, the spacecraft will have an S-band transmitter with 30dBm output power, alongside the VHF telemetry transceiver. To minimize the effects of antenna radiation pattern and thus improve the radio link a redundant attitude determination and control system (ADCS) will be implemented with optical, magnetic and kinetic sensor determination and magnetic control.
Remote sensing such small objects is a challenge for radars that track them around the planet. To propose a solution for the problem, a new satellite beacon system will also be implemented, which will provide the ground stations accurate TLE (Two-line Element) data based on GPS location of the spacecraft. [1]
We will also experiment with receiving Automatic Identification System (AIS) packets and relay them to our ground station. This system is responsible for tracking vessels out on the sea (not exclusively), where the coverage does not reach mainland because of the propagation properties of the frequency used. To increase this coverage, cheap satellite relays (e.g. a PocketQube) could be a solution. [2]
The project is integrated into the education system, as the developers are either university students or lecturers of BME. Our guest experiments come from different universities, institutes and companies of Hungary and their payloads include Sun and Earth horizon sensors by Konkoly Observatory, a RAM based

* corresponding author

event detector by the University of Debrecen, a compact total ionizing dose measurement by 27G-Technology Kft., thermal insulation material experiment by H-ION Kft. and further experiments by the University of Szeged and the Széchenyi István University. The preliminary launch date is the end of 2022, so the development is quite critical timewise.

Keywords:
pocketqube, satellite, electrosmog, earth observation, remote sensing

References:
[1] Speretta, Stefano & Sundaramoorthy, Prem & Gill, Eberhard. (2017). Long-term performance analysis of NORAD Two-Line Elements for CubeSats and PocketQubes.
[2] WHITE PAPER: UNDERSTANDING SATELLITE AIS AND THE SDPOB ADVANTAGE

GNSS interference events at Hungarian airports

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In the frame of PBN4HU (Performance Based Navigation for Hungary) project, funded by CINEA (European Climate, Infrastructure and Environment Executive Agency), satellite-based procedures were developed and published for seven civil and three military airports in Hungary. Following ICAO (International Civil Aviation Organization) Annex 10 recommendations for GNSS signal monitoring, ICAO EUR Doc 25 for spectrum check performance and ICAO State Letter 089 (2020), a network of permanent GNSS (Global Navigation Satellite Systems) stations were deployed at those airports to monitor the performance of EGNOS (European Geostationary Navigation Overlay Service) augmented positioning.
In addition to satellite positioning, the GNSS frequency ranges are also monitored by GNSS receivers with spectrum monitoring capability in order to detect and log all the interference events that might affect aviation activity. Although international laws declare that in the frequency ranges dedicated to satellite positioning, no signals are allowed to broadcast, a great many events have been recorded over the past few years when GNSS satellites could not be tracked even though there was a clear view to the sky. These situations are mainly attributed to low-cost GNSS jammers, which broadcast signals to block or interfere with signals from real GNSS satellites making positioning impossible nearby. Even though the devices are entirely illegal, their number has been soaring. The majority of the users apply them with the intention to block the positioning of the receivers built in their own vehicle. On the other hand, they are not aware of

* corresponding author

the fact that their activity might have a serious impact on other applications, as well. First and foremost, safety-of-life applications, such as aviation, are somewhat sensitive to this kind of issue.
From what has been discussed above, GNSS vulnerability has recently become one of the gravest concerns. Our presentation summarizes the main features of interference events recorded in the Hungarian E-GNSS network and their impact on the performance of satellite-based augmented positioning.

Keywords:
satellite positioning, GNSS, safety-of-life-applications,
interference events, jamming, spoofing

How Tech Companies can help to Teach Space

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Nowadays the vision of a tech company is not just to change the world with their unique ideas. The route to get to this goal is more and more part of the vision itself. Most of the technologies that we use and build upon to make this change originate in one way or another from the Space industry. The skill required to build products that make this change is also heavily based around the education of STEM. We as a company focusing on the digitalization of aquaculture benefit from many of these technologies. Our product team finds it important to popularize STEM in High Schools and tries to achieve it using Space as the topic to "break the ice" and get students interested.

Our products involve the development of both hardware and software solutions. We have connections with multiple schools in our area and occasionally give some lectures on programming and building small electronics projects. Some of the founders of our company participated in the European Astro Pi challenge in their time at High School.

The Astro Pi Mission is a great way to teach students the importance of coding, and teamwork in both scientific experiments and product development projects. Problem solving is probably the most important part of programming. Mission Space Lab lets students code their own experiment and run it on the ISS for 3 hours. This makes students think what information they want to get back and why thus enhancing their creative skills.

In the fall of 2021, we decided to mentor an Astro Pi Mission Space Lab team as a coding club. The students decided to use the newly upgraded Astro Pis to identify and analyze clouds with the help of machine learning. They will take into account clouds, the patterns and colors of ground to identify which areas are the best for placing ground-based telescopes. Because of the strict data cap, all images will be filtered and nighttime images with no useful data will be deleted.

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The team right now is in phase 2, coding their experiment. Our experts are helping them with their questions, testing code, and checking compliance with the rules. We are hoping to get another Hungarian experiment to flight, after the successful missions in 2017, 2019 and 2020.

Keywords:
Astro Pi, education, Ultimate Waterprobe, research-based teaching

References:
[1] Astro Pi Website, http://astro-pi.org
[2] UltimaSpace Website, http://ultima.space/
[3] Ultimate Waterprobe Website, http://ultimatewaterprobe.com

Hungarian Participation in JUICE Mission of ESA

János Nagy*[1], László Hevesi[1], Pál Gábor Vizi[1], Lajos Szalai[2], István Horváth[2], Sándor Szalai[3]

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JUICE - JUpiter ICy moons Explorer – is ESA's most significant flagship interplanetary mission. The spacecraft is scheduled to launch in August 2023 and will arrive to Jupiter in 2031, where it will spend three years observing Jupiter's giant gaseous planet and its three largest moons, Ganymede, Callisto and Europe. The Space Technology Group has developed a power supply for the Particle Enviroment Package (PEP) instrument. PEP sensors examine the plasma environment of the Jupiter system. PEP measures the density and fluxes of positive and negative ions, electrons, exospheric neutral gas, thermal plasma and energy neutral atoms. The nominal on-board voltage on the spacecraft is 28V. The Space Engineering Group was responsible for the development of the Direct Current Converter (DCC) power supply unit for PEP's computer, communication channels and sensors. The task was a major challenge due to the high degree of reliability expected, and reliable operation had to be ensured even in extreme conditions. We present the development and implementation of DCC. The development of a special test equipment, Electronic Ground Support Equipment (EGSE), which simulated the operation of PEP, was also required to test DCC. EGSE was developed by SGF Ltd. It made it possible to control DCC. In this article, we present DCC, quality assurance methods and EGSE testing. This article reviews the structure of the DCC unit, design requirements and specifications that had to be met. We present the important steps of quality assurance, the technological specification of the production, the EGSE, as well as stress tests and integration.

Keywords: JUICE, DCC, PEP

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InSAR monitoring results of Transcarpathia in the GeoSES Project

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One of the main objectives of the GeoSES** project to monitor anthropogenic and natural geo-processes, using space geodetic technologies and concentrating on Transcarpathia and the Hungary-Slovakia-Romania-Ukraine cross-border region.
In the framework of the presented project, our study utilizes one of the fastest developing space-borne remote sensing technology, namely InSAR, which is an outstanding tool to perform large scale exploration of ground displacements and to conduct related observational and monitoring tasks. Performing such monitoring task, we analyzed ascending and descending Sentinel-1 Level-1 SLC acquisitions since 2014 until 2021 over the indicated region.
We also present an automated processing chain of Sentinel-1 interferometric wide mode acquisitions and related pre-processing workflow to generate long-term ground deformation data. To retrieve displacement time series from co-registered SLCs stacks, we have performed multi-reference Interferometric Point Target Analysis (IPTA) [1] using singe-look and multi-look phases using the GAMMA Software [2]. According this, phase terms related to both topography and orbit, as well as the non-linear large scale phase component, including the APS and the height dependent phase component have been evaluated and refined though an iterative process. After considering such phase terms, to retrieve recent deformations of the investigated area, SVD LSQ optimization has been utilized to transform the multi-reference stack to single-reference phase time-series such could be converted to LOS displacements within the processing chain. The derived results are through regional scale and local examples of the introduced cross-border region as well.

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** Hungary-Slovakia-Romania-Ukraine ENI Cross-border Cooperation Programme (2014-2020) “GeoSES” - Extension of the operational "Space Emergency System"

Keywords:
Sentinel-1, InSAR, GeoSES, hazard detection

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Investigating Cognitive Changes in Space Analog Paradigms

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Optimal cognitive function is crucial for astronauts during spaceflight, however, weightlessness is an extreme environment for humans and can have health consequences even under a short period of time (De La Torre, 2014; Takács et al, 2021). It is therefore important to explore potential spaceflight related negative effects and to identify tools and procedures to effectively counteract them. Because of the difficulty of studying changes in microgravity space analog paradigms are often used which can effectively model the majority of space related changes under terrestrial conditions. Results from space analog experiments not only provide useful insights into how the brain works in space, but also help us to better understand the results of experiments on the ISS too as they provide a controlled environment in a more affordable and available way for scientists. Further, they are also beneficial for the preparation for future space missions as they offer an opportunity to test and validate countermeasures which helps in mitigating the negative impacts of long-duration space missions.

One such Earth-based condition is the isolated, confined, and extreme (ICE) environment paradigm which can be used to investigate how mental health or psychological state is affected by different stressors (Ehmann et al, 2018). Another space analog is the bed rest paradigm, in which volunteers lie in bed for shorter or longer periods in a position tilted 6° towards the head (Head Down Tilt Bed Rest - HDBR). HDBR causes similar physiological changes in the human body as microgravity as it mimics headward fluid shift, cardiovascular, sensory-motor deconditioning, etc (Pavy-Le Traon et al, 2007). Thus, HDBR is suitab-

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le for investigating cognitive functions and changes in neural activity in space analog environments. Our research group studies cognitive changes in extreme environments, including in these space analog paradigms. We have investigated cognitive performance in the Artificial Gravity Bed Rest ESA study to better understand how HDBR and space can affect cognition. Our results may offer insights into how we can use artificial gravity to mitigate the negative effect of weightlessness.

Keywords:
space analog paradigms, cognitive performance, bed rest

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IRF SpaceLab – a Swedish example of opening research infrastructure for external users

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The Swedish Institute of Space Physics [1] (IRF) have been developing scientific payload for space missions for over 50 years [2]. During this time, the institute's test facility has evolved to comprehensive infrastructure, capable of testing, qualifying and calibrating these instruments.
As a response to the growing space industry and the increasing demand for space environmental testing, the institute is in the process to open up its laboratory – the IRF SpaceLab [3][4] – for external users. The main goal of the lab remains to serve the research projects at IRF, but the remaining capacity is now offered for external customers. Users can perform individual tests or complete campaigns combining mechanical, TVAC, solar balance and TID tests, and benefit from the decades of know-how accumulated by IRF's staff. In the meantime, IRF SpaceLab generates income for the institute, dedicated to cover maintenance costs and further expansion of the facility.
However, as a governmental research institute, providing services for a fee is legal grey zone, and administrative bottlenecks had to be solved before IRF SpaceLab could be fully opened.
Besides these difficulties and their solutions, the presentation aims to introduce the institutes history and current activities, describes the current test facilities and reveals the near- and long-term expansion plans.

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Keywords:
Space physics, environmental testing,
commercialization

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Limits of ion-trajectory controll using electric field

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In this paper we are dealing about controllability of ion swarms in a small satellite ion thruster. Small satellites are a new and forward-looking trend of satellite development. Such a small device's life time is mainlz effected by its ability to change its position and location. Most of small-satellites do not have a propelling system. Ion-thrusters are a possible system that have small fuel consumption, long lifetime and high reliabiliy. Their disadvantage is that ion particles have to be condition to achieve precise control.
Ion thrusters are small ion canons where ions of ionized gas are accelerated and shooted outward to achive thrust force. These ions have to be controlled to achieve steering capability. It was earlier shown[1] that these ions can be forced to follow a predetermined path through the nozzle of the thruster. We use electrodes mounted on the nozzles' surface to controll ion movements. Level of controll depends on the speed and total energy of ion-packets. Voltage of controll-electrodes are calculated using a machine learning algorithm based on the previously defined ion-path through the nozzle. [2]
In this paper we examine the limits of the controllability of ions using only electric field generated by controll electrodes' potential. It is inspected what the limits of pre-defined path are. The error is the difference between pre-defined path and the simulated trajectory [3].

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Based on this, we modify the electrodes potential, to minimize the error, in quadratic mean with machine learning algorithm. We tested two scenarios: using only electric field or using both electric and magnetic field.

Keywords:
small satellite, ion-thruster, optimization, machine-learning

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Miniaturized and modular flow chemical reactor for space applications

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In recent years, chemistry and drug discovery related research in space has gained progressively increasing popularity. This trend could be somewhat predicted, considering that in parallel to the rapid development of the space industry, chemistry related research and applications have become organic part of space research and also space manufacturing.
Performing drug discovery in space offers a huge opportunity for us, both on Earth and also for future space travellers. Microgravity may ensure faster, more efficient reaction routes, even novel active pharmaceutical ingredients which are difficult to synthesize on Earth. The on-demand pharmaceutical production in space, that will be a huge support for example, for long-term space travellers, seems to be an important technology to be developed, due to the known pharmaceutical stability problems occurring in space.
For this purpose, flow chemical reactors are designated which are operable under microgravity, completely automated and remotely controllable, and can ensure the required reaction parameters, efficient mixing of fluids and reliable operation. The technology itself, however, has not yet been well-established under microgravity conditions, mainly due to the lack of: scientific background for chemical technologies in space; appropriate reactor design; assembling; and also, implementation.
Thalesnano has developed a miniaturized and modular flow chemical reactor that is able to perform liquid-liquid, gas-liquid, heterogeneously catalysed, photochemical but also electrochemical reactions, and targeted for microgravity applications. The reactor design is feasible to in-line join analytical tools in order to execute chemical analyses in space. Although originally designed onto ESA's Space Rider, the reactor equipment prototype is feasible for upscaling for commercial in-space pharmaceutical manufac-

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turing purposes and also, is contingently convertible to diverse in-space manufacturing processes (e.g., polymer production) or to chemical technologies required by asteroid mining.
The aim of this presentation is to give an insight to the most recent chemistry related developments for space applications, focusing on the key elements, results and expected impact of Thalesnano's space reactor development project.

Keywords:
space chemistry, flow reactor, drug discovery, microgravity, in-space manufacturing

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Nationwide Ground Motion Map of Hungary Based on Sentinel-1 PSI Data

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Since the launch of the first Sentinel satellite, Sentinel-1A in April 2014 more than seven years of Synthetic Aperture Radar (SAR) observations are now available and the Sentinel-1 tandem ensures a reliable, growing dataset for various applications. Sentinel-1 is designed to be particularly effective in wide area persistent scatterer (PSI) analysis for long-term stability and deformation analysis. In recent years, a few countrywide PSI motion maps have already been created by national agencies, large companies and consortia in European countries like Italy, the Netherlands. and Norway. These projects prove that there is a great demand for deformation information from Sentinel-1 data and also show that the construction of a national PSI deformation map is feasible.

Compared to these, our approach is not based on large-scale, semi-automatized, robust processing of the incoming data flow, but high resolution, precise, individual processing of relatively smaller regions. The persistent scatterer SAR data processing is entirely done by the Gamma software from Single Look Complex (SLC) data to displacement time series, using a single master approach. The dataset includes all Sentinel-1 observations since 2014, but some individual patches cover different timeframes from 2.5 to more than 6 years.

An important issue is the combination of these independently processed areas to have a relatively homogeneous, common referenced, consistent large-scale PSI database. We investigated a few approaches including the matching of overlapping regions as well as using a multi-technique (InSAR, GNSS, levelling) reference point network. Several different validation works have also been performed across the country.

This work is also meant to be a demonstration that the technology is adequate to create a PSI velocity map of the whole country with modest resources. Scaling it up in terms of automatic

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processing algorithms, improved data management, providing higher-level products and better dissemination are some of the next technical steps and we also plan to complement PSI method to have even better coverage outside urban areas, better homogenization of the dataset and regular reprocessing of selected areas. Hungary is mostly characterized by large plains and its area is dominantly covered by soft sediment, its topography is gentle and the tectonic activity is moderate. Thus, our results are generally reflecting ground motions associated with anthropogenic activities, related to mining, oil, gas, and water exploitation and civil engineering, etc. However, motions of natural origins like landslides, soil creep, erosion, compaction, swelling clay also appear.

Keywords:
Sentinel-1, Ground motion, Hungary

QO–100 video signal transmitting

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In our presentation we would like to introduce how to transmit video signal over a geostacionery satellite with simple devices. Besides we are going to describe the QO-100 satellite and its services. We will specify the meaning of DATV, then detail the devices and the connection of them that are required for the transmission. Then you can examine with us a link budget calculation. After that in a video we will present our headend wherewith we made the transmission. We are going to detail the path of the communication and show a part of the video we aired. Then we will talk about the challanges and obstacles we had during the implementation of the system. At the end you can observe the built-up station virtually.

Keywords:
QO-100, video signal transmitting, amateur radio

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Radio astrometric support for the JUICE mission to Jupiter

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The European Space Agency (ESA) will launch its large-class JUICE (Jupiter Icy Moons Explorer) mission towards the Jovian system in 2023. The primary science targets of JUICE will be three of the Galilean moons (Ganymede, Callisto, and Europa) of the giant planet that appear to have oceans of liquid water under their icy crusts. One of the JUICE science experiments is PRIDE (Planetary Radio Interferometry and Doppler Experiment) which will enable highly accurate position determination of the spacecraft by means of observing the carrier signal of its radio transmitter, to help achieving many of the interesting science goals of the mission.
The lateral position of JUICE will be measured with a global network of radio telescopes using the technique of very long baseline interferometry (VLBI), relative to compact, distant extragalactic radio sources that serve as virtual reference points in the sky. In the framework of ESA PRODEX (Programme de Développement d'Expériences scientifiques), we recently started a project with the aims of defining the optimal phase-referencing strategy, assembling an inventory of suitable reference objects, and densifying the network of celestial radio sources with new observations along the spacecraft trajectory. Here we briefly introduce JUICE, PRIDE, and present some details of our work in the project.

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Keywords:
Jovian moons, JUICE, VLBI, phase-referencing,
reference frame

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Rain Field Sensing Supported by GPS Signal Attenuation

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The amount of rainfall over a specific geographical area is an important factor in the agriculture, in water management systems, or in air traffic control, but the design of the sewer network in cities also relies on long-term precipitation data. Radio communications systems are also suffer from high signal attenuation, especially in the millimeter wavelength range. The backbone network of the cellular mobile systems [1] or high frequency satellite communication links are highly attenuated by rainfall.
In order to ensure the quality of radio connections are often applied adaptive technologies based on the instantaneous knowledge on the present weather conditions.
There are numerous techniques available for rain field sensing. An array of ground-based rain gauges is a simple but device-intensive solution. Among of other methods, meteorological radars are widely applied for real-time rain field sensing.
Hydrometeors, especially the rain cause the major part of the attenuation on Earth-space radio links.
In [2] the relationship of the rainfall rate and the attenuation can be found up to 55GHz frequencies. With an inverse method by measuring the attenuation, the rainfall rate can be expressed, thus satellite radio signals are applicable to estimate the cumulated rain intensity over a specific path. If multiple measurements can be performed over different viewing angles, a tomographic method is applicable [3] to reconstruct the rain field

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structure. The method was also proved with a constellation of geostationary satellites [4] and the tomographic rain field reconstruction was proved by simulated rain zones over an existing geographical area.
Receiving GPS satellites on medium earth orbit is well applicable for the above mentioned tomographic rain field reconstruction. These satellites are operating in the UHF frequency band, using code-division multiple access (CDMA) by transmitting pseudo-random (PRN) sequences. The quality of correlation provides sufficient information to estimate the attenuation over the radio path, thus the cumulated rain intensity can also be detected. By passing the satellite on its orbit different cross sections of the rain field is scanned and by using equidistant measurements along the orbital positions a tomographic rain field reconstruction can be foreseen.
To prove the concept, software defined radio based measurements will be performed to test and evaluate the method.

Keywords:
rain field, tomography, satellite link, attenuation

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Simulated Mars Rover Model Competition – Years of Pandemic Challenge

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We had to cancel our race in 2020 and 2021 because of COVID, so we asked teams to send us online material about their solutions. We presented our competition at LPSC and domestic conferences. [1]
2020&2021 The goal was to use mechanical 3D knowledge and printing, a rover and its manipulators [1]. According to the framework story, the 'The Martian' movie's Mark Watney had to be rescued. Even in the event of a pandemic, we had to find the advantage for the competition, so we could see the development and testing phases of the groups. The top three teams have all finished first in 2021.
KissBé: "Winner of the year". Elementary and high school students and their father, who a robotics teacher. The robot: 4 wheel drive. 3-cell LiPo battery 2000 mAh. Grapple collects in a container at the touch of a button. Automatic acceleration. 180 degree FPV camera. Two limits switches on the sampling arm. 3 Arduino: motor controllers, central unit with HC-12 receiver, ToverPro MicroServo 99S, laser rangefinder. The collecting arm saved Watney. [2]
DeltA2: "Champion of the year". The first competitor started the university in 2010, the team have achieved excellent positions. DeltA2 also worked with Arduino kits. 28BYJ-48 stepper motor with ULN2003 drive. Autodesk Fusion 360 for 3D printing and design. Robot arm programming and test phases can be tracked on their video using the Arduino Developing on their screen. [3]
µ-troll: "Winner of the year". The µ-troll started in 2015 and have been in the top five. Arduino CNC-Shield panel, TowerProsg90 servo180 and ZippyFlightmax 1500mAh Li-ion batteries. [4]
2022 Plans A and B. A is to have our usual race in a real place at Óbuda University. B is to have our unusual race in the virtual space with CAD-CAM solutions, which have to arrive in digital

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form to the organizers in time. Task: to construct a robot car with omniwheels and a 'camera targeted laser' on a telescope which is moved by a servo motor up and down to adjust the height of the horizontal laser gun. The goal is to control the rover near the pillars, targeting the sensors at the inner end of the pipes. [5]
Conclusion: 2020-2022 were years of the "rescue obligation", to rescue the troubled Watney and the Competition had to be saved so that it could work despite the restrictions of the pandemic with Plans A&B.

Keywords:
Competition Applied Sciences Simulated Marsrover

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Székely Mikó T3Ki-rover

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This paper presents a school project which helps to combine theoretical knowledge and students' creative and engineering skills in a STEM activity. The topic is applied in Science Club activity mostly through inquiry and project-based teaching method. The goal is to develop students' competencies in a way that is interesting and fascinating to them. Students 'interest in space exploration topics has always been very lively, but it has been revived especially since the start of the mission of the Mars explorer Perseverance rover and James Webb Space Telescope. However, as the compulsory Physics curriculum does not include such topics, ESA and NASA projects for students and their application to specific school conditions are a good help in classroom work.
High school students at our school built a Perseverance-type rover to compete in the Exo-rover competition in 2021. The rover task was the same as a space exploration mission to discover an alien celestial body: atmospheric measurements, digital photos and data collection from the surface, followed by transmission to the control and processing center. This project offered Science Club members a great opportunity to apply their knowledge of mathematics, computer science, and physics in a challenging way. Additionally, they gained knowledge of new concepts, such as astrobiology or astrochemistry.

Keywords:
education, STEM, space related topic, microcontroller

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The Jovian Plasma Dynamics and Composition Analyzer (JDC) - a sensor of the Particle Environmental Package (PEP)

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The Swedish Institute of Space Physics (IRF) delivered two of the ten scientific payload for ESA's first L class mission; the Jupiter Icy Moons Explorer (JUICE): the Radio and Plasma Wave Investigation (RPWI), and the Particle Environmental Package (PEP)[1].
PEP is designed to perform in-situ measurements of the plasma environment around Jupiter and its icy moons, in order to understand better the dynamic processes in the Jovian magnetosphere and the particle environment around three of Jupiter's moons: Ganymede, Callisto and Europa. PEP is developed by an international consortium, and consists of six sensors and a common electronics rack.
One of the six PEP sensors, the Jovian Plasma Dynamics and Composition Analyzer (JDC)[2] measures positive and negative ions together with electrons in an energy range between 1eV/q and 40keV/q. JDC is a completely new instrument design tailored to do measurements in the harsh Jovian radiation environment.
The presentation briefly introduces the JUICE mission and PEP, and gives an overview of JDC's science objectives, performance figures, main working principles and the technical development from the design stages to integration of the flight model to the JUICE spacecraft.

Keywords:
Space physics, Plasma physics, JUICE, Particle detector

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Topic discovery in the diaries of Antarctica winteroverers with multilingual deep sentence encoders

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Overwintering in Antarctic outposts is one of the terrestrial models of Isolated, Confined and Extreme (ICE) environments pertinent to long duration spaceflight. In the CoALa project, overwintering crews of Antarctic research stations recorded weekly video diaries. The transcripts of these French, Italian and and English diaries have been analyzed with language processing tools with the long-term goal of automatically monitoring psychological processes and dynamics in isolated groups working in extreme circumstances.

We applied a fully data-driven method for discovering topics in the multilingual collection of diaries. In the past few years, deep language models revolutionized all aspects of language processing/understanding, including the task of sentence embedding, that of representing sentences in a linear vector space of a few hundred dimensions. Multilingual models map the sentences of 50–200 languages to a common latent space.

To avoid the bias of research preconceptions, we apply the unsupervised method of clustering to form groups of similar sentences in the semantic space. We opt for the hierarchical density -based clustering method HDBScan. In order for the density of the cloud of sentence encoding vectors to make sense, it is advantageous to map the vectors in a lower-dimensional space, say 32. Non-linear dimension reduction methods like t-SNE, UMAP and DensMAP aim to optimize the trade-off between preserving global and local properties of the sentence cloud. DensMAP improves its forerunners by better preserving density as well, which is especially important for HDBScan. We interpretat the clusters approximately by assigning them key-words.

While dimension reduction is indeterministic and our method has many hyper-parameters which may influence the results,

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some large clusters of sentences seem to be stable, and these correspond to interesting topics. Examples below show one of the key-words (French, English or Italian) and a short post-hoc description.

- sommeil: how the speaker has slept
- groupe/comunque: the speaker's emotions about people; roles and conflicts in the group
- winter: snow and winter
- lune: sky phenomena (sun, moon, horizon, Aurora, etc.)
- cuisinier: cooking and eating
- settembre: expedition time on the large scale, plans (e.g. It's been six months, six months since I left home, since I left Lyon.)
- koala: meta-sentences of diary writing ("Hallo, CoALa. This week's been an OK week. ... I still have five minutes.")
- vent: weather (wind, temperature, etc.)
- engine: equipment (engine, tank, cleaning, computer, pump, etc.)

We touch on describing the connection between each cluster and the participants' emotions/sentiments, and on how freqently and in which valuation each cluster is mentioned over time.

Keywords:
clustering, deep language models

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Using quantum algorithms for Earth Observation data processing

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Big data is collected these days from various sources including sensors and cameras and contains important information about space, weather, medical application, industrial application, etc. Such information requires processing and storage memory, limited ability of classical computers make it hard to deal with such huge amount of data. Quantum algorithms offers revolutionary solutions in various domains which require complex computational steps.
In our paper, we introduce selected quantum algorithms which can be run on quantum computers soon to support the data handling process for images arriving from Earth Observation satellite. We briefly present a potential application area named quantum image processing (QIP) which could be utilized to enhance the data processing operation while handling Earth Observation data. The novel idea of QIP is aimed to apply principles of quantum physics such as superposition, entanglement, and parallelism to the image processing applications. instead of using classical algorithms. This will be able to solve many problems, reduce computational complexity and exponentially speed up compared to the classical one, no matter how large the amount of data we deal with. Future's quantum computer will be able to perform the algorithms of QIP such as image representation, detection, etc. and break the classical limitation of calculation.

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Keywords:
quantum computers, quantum algorithm, image processing

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