Hackathon as a Format for Teaching Modern Geodesy

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SUMMARY

Geodesy, the science of accurately measuring and representing the Earth, has evolved significantly in recent years, encompassing advancements in satellite technology, data analysis, and computational methods. However, traditional geodesy education often struggles to keep pace with these rapid developments, leaving students ill-prepared to apply their theoretical knowledge to real-world challenges.

Hackathons offer a unique and engaging format for teaching modern geodesy that combines theoretical knowledge with hands-on problem-solving. Hackathons are typically short-duration events (often 24-48 hours) where participants collaborate on real-world projects, using their skills and creativity to solve challenging problems. This format is well-suited for teaching modern geodesy, as it encourages participants to apply their theoretical knowledge to practical problems, while also fostering teamwork and collaboration.

This article discusses the use of hackathons as a format for teaching modern geodesy.

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1. INTRODUCTION

Geodesy, the science of accurately measuring and representing the Earth, has evolved significantly in recent years, encompassing advancements in satellite technology, data analysis, and computational methods. However, traditional geodesy education often struggles to keep pace with these rapid developments, leaving students ill-prepared to apply their theoretical knowledge to real-world challenges. This is particularly true when geodesy is only part of the training of more practically orientated professionals, such as surveyors. In some countries, though, the two educational programmes are closely integrated and graduates choose their career path only in their final years of study or even after the graduation.

Individual student engagement in the educational process is also a difficult task due to the different levels of student's backgrounds, the large number of students per teacher, and the many distractions in the form of smartphones with unlimited access to entertainment resources. In other words, the teacher competes with the global entertainment industry for the student's attention both during class hours and outside of class, during the self-work hours. All these are common problems of modern education, which have not bypassed the training of geodesists.

Hackathons offer a unique and engaging format for teaching modern geodesy that combines theoretical knowledge with hands-on problem-solving. Hackathons are typically short-duration events (often 24-48 hours) where participants collaborate on real-world projects, using their skills and creativity to solve challenging problems. This format is well-suited for teaching modern geodesy, as it encourages participants to apply their theoretical knowledge to practical problems, while also fostering teamwork and collaboration.

2. UNDERSTANDING THE HACKATHON FORMAT

Hackathons have emerged as a dynamic and popular format for learning, innovation, and collaboration. These events bring together individuals with diverse skills and backgrounds to tackle challenging problems or develop innovative solutions. In the realm of education, hackathons offer a unique approach to teaching modern geodesy, fostering hands-on learning, teamwork, and creative problem-solving.

2.1 Definition of hackathons and their objectives

Hackathons are essentially time-bound events where participants, often self-organized into teams, engage in focused development of projects or ideas. These events typically last for a day or two, providing a concentrated period for rapid prototyping and innovation.

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The objectives of hackathons vary depending on the organizers and participants but often encompass:
–   collaborative problem-solving: hackathons encourage teamwork and collaboration, as participants work together to identify problems, brainstorm solutions, and implement their ideas;
–   hands-on learning: hackathons provide an immersive environment for applying theoretical knowledge to practical applications, fostering deeper understanding and skill development;
–   creative innovation: hackathons nurture creativity, encouraging participants to think outside the box and develop unconventional solutions to problems;
–   building prototypes: hackathons provide a platform for rapidly prototyping ideas, allowing participants to test their concepts and gather valuable feedback.

2.2 Typical structure and duration of hackathons

Hackathons typically follow a structured format that guides participants through the ideation, development, and presentation of their projects. The specific stages may vary, but a general outline includes:
–   registration and introduction: participants register, receive an overview of the event, and are introduced to the project theme or problem statement;
–   team formation and idea generation: participants form teams, brainstorm ideas, and refine their project concepts;
–   development and coding: teams dedicate their time to developing their project prototypes, using various programming languages, tools, and resources;
–   feedback and iteration: teams receive feedback from mentors and peers, making necessary adjustments and improvements to their prototypes;
–   presentation and evaluation: teams present their final project prototypes to a panel of judges, who evaluate their innovation, problem-solving, and overall presentation.

The duration of hackathons varies depending on the organizer's goals and the complexity of the projects. However, most hackathons typically last for 24-48 hours. Educational hackathons can last longer due to students' workload with other subjects and tasks. The optimal period can be the usual period of 1/2-2 weeks between classes according to the current schedule.

2.3 Emphasizing the collaborative and hands-on nature of hackathons

Hackathons are characterized by their collaborative and hands-on nature, fostering a dynamic environment where participants learn from each other, share ideas, and work together to achieve shared goals. This approach contrasts with traditional classroom settings where learning is often focused on individual effort and passive instruction. The hands-on nature

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of hackathons directly engages participants in the learning process, enabling them to apply their knowledge and skills in real-world scenarios.

3. BENEFITS OF HACKATONS IN GEODESY EDUCATION

Modern geodesy, a dynamic and evolving field, demands a pedagogical approach that equips students with practical skills and critical thinking abilities. Traditional classroom methods, while valuable, often fall short in providing students with hands-on experience and opportunities to apply their knowledge to real-world scenarios. Hackathons, on the other hand, emerge as a transformative format for modern geodesy education, immersing students in authentic learning experiences that bridge the gap between theory and practice.

In modern geodesy, the amount of measurement data that needs to be processed has increased markedly over the last decades and this trend continues. On the other hand, existing software, both commercial and freely available, is not always honed and adaptable to the large volume of data, as well as the inclusion of new type of data and formats. All this suggests that geodesists and surveyors often need to either modify an existing code base or develop their own from scratch to solve their problems, both scientific and practical.

Therefore, the skills of programming, software development and correct solution of computational problems are important competences of a geodesist and a surveyor, and therefore should be part of the educational process when training such specialists.

Hackathon as a class format has proved to be an effective way to involve students in solving specific problems in a limited period of time and with a limited and pre-selected set of tools. At the same time, learning tools, such as programming languages, is not an end in itself, but rather a positive side effect.

At the heart of hackathons lies the power of experiential learning. Rather than passively absorbing information, students actively participate in projects that challenge them to apply their theoretical understanding to solve real-world problems. This hands-on approach fosters deeper comprehension and practical skill development, preparing students for the complexities they will encounter in their professional careers.

Geodesy, by its very nature, is a collaborative field, both interpersonally and internationally. Projects often involve diverse teams working together to achieve common goals. Hackathons, by creating a dynamic and supportive environment, cultivate essential teamwork skills in students. Participants learn to communicate effectively, share ideas, and collaborate effectively to overcome challenges. These skills are invaluable in the geodesy, where successful projects depend on the ability to work effectively with others.

The spirit of innovation is at the core of modern geodesy. Hackathons, with their open-ended nature and emphasis on creativity, provide a fertile ground for students to develop their

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innovative potential. Participants are encouraged to think outside the box, explore unconventional approaches, and challenge conventional thinking. This stimulating environment fosters a culture of innovation that is essential for driving progress in the field.

The competitive and fast-paced nature of hackathons creates a demanding environment that promotes rapid decision-making, adaptability, and effective problem-solving skills. Students are faced with time constraints and the need to make quick choices, honing their critical thinking abilities and adaptability in the face of challenges. This pressure-cooker environment mirrors the real-world demands of geodesy, preparing students to navigate complex projects and challenges under time pressure.

4. DESIGNING THE HACKATHON

The secret to a successful hackathon lies in the careful planning of the event by the educators and the involvement of the students.

4.1 Background

We describe the experience of using the hackathon format to teach courses in higher geodesy at Moscow State University of Geodesy and Cartography (MIIGAiK) for students who have no experience in solving geodetic problems using programming. Python was chosen as a programming language of the course due to its simplicity and numerous available training materials and scientific packages. The use of Python was not strictly mandatory, students could choose their own programming language.

Due to the student's lack of experience, the entire course started with learning the basics of Python programming language. Simple and already known algorithms, such as coordinate transformations, were given as training tasks. At the same time, the complexity of the tasks was higher than the already familiar ones and required combining knowledge and developing their own more complex algorithms based on the simpler ones. Thus, the students gradually got used to the hackathon format, but still in the familiar environment of a regular classroom. The same factor was a limiting factor, as only one or several real hackathons could be done during the semester.

4.2 Planning

– Define goals and objectives: clearly articulate the hackathon's purpose, whether it's to enhance hands-on learning, foster creativity and collaboration, or prepare participants for real-world applications. Ensure the hackathon aligns with the educational goals of the target audience, such as introducing new concepts, enhancing technical skills, or developing problem-solving abilities.
– Choose a relevant project theme: Select a theme that aligns with current advancements in geodesy, sparks interest, and is relevant to the target audience.

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- Establish a timeline and schedule: develop a detailed timeline with clear timelines for registration, project ideation, development, feedback, and presentation. Set realistic deadlines to ensure participants have ample time to work on their projects without feeling overwhelmed.
- Identify and secure resources: secure access to relevant geodetic data sets, acquire licenses or access to commonly used software tools and programming languages in geodesy, such as Python, and GIS software. Find a suitable venue with adequate space for collaboration, presentations, and networking events.
- Develop a communication strategy: utilize online platforms like social media, university websites, and online forums to reach your student.

4.3 Preparation

- Organize workshops and training sessions: Conduct introductory workshops on fundamental geodetic concepts, such as coordinate systems, geodetic surveying methods, and statistics. This can be done as part of the regular classroom activities during the course. Offer training sessions on relevant programming languages, software tools, and data analysis techniques used in geodesy. If it's possible, invite experienced geodesists or professionals in the field to conduct hands-on workshops or provide mentorship to participants.
- Foster a supportive and inclusive environment: Establish clear guidelines for respectful and inclusive collaboration, ensuring a welcoming atmosphere for all participants. Create opportunities for participants to network with each other, mentors, and industry professionals. Encourage peer support by promoting the exchange of ideas and constructive feedback among teams.
- Establish judging and evaluation criteria: Recruit a panel of experts in geodesy, programming, and project evaluation to assess participant's work objectively. Define clear criteria for judging, encompassing creativity, innovation, technical feasibility, and alignment with the hackathon theme.
- Facilitate post-hackathon engagement: Maintain online communities or platforms where participants can continue to connect, share their work, and collaborate. Organize follow-up events, such as networking gatherings or workshops, to maintain connections and provide ongoing support for participants. Promote further learning resources, such as online courses, tutorials, and community forums, to encourage continued learning and exploration.

4.4 Hackathon

- Engaging participants and facilitating collaboration: a hackathon's success hinges on the engagement and collaboration of its participants. Encourage participants to form diverse teams, ensuring a balance of skills and perspectives. Facilitate teamwork by providing dedicated team collaboration spaces and encouraging regular interactions.

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- Guided ideation and brainstorming: initiate brainstorming sessions to generate creative project ideas. Encourage participants to explore unconventional approaches and consider real-world applications of geodetic concepts. Provide access to relevant software tools, programming languages, and geodetic datasets. Offer workshops and tutorials to introduce participants to new skills and techniques.
- Hands-on learning and skill development: provide access to relevant software tools, programming languages, and geodetic datasets. Offer workshops and tutorials to introduce participants to new skills and techniques.
- Peer mentorship and support: encourage peer mentoring and support among team members. Establish a mentorship program to connect experienced geodesists or programmers with participants.
- Regular feedback and iteration: facilitate regular feedback sessions for teams to refine their projects and address any challenges. Encourage participants to iterate on their solutions based on feedback.
- Engaging workshops and challenges: organize workshops on specific geodetic topics or introduce challenges to encourage participants to apply their knowledge in creative ways.

4.5 Post-Hackathon

- Organize presentations and exhibitions: host a final presentation event for participants to showcase their projects, receive feedback, and connect with industry professionals. Encourage participants to create engaging presentations that effectively communicate their project's objectives, methodology, and outcomes. Organize an exhibition space where participants can showcase their projects to a wider audience, including potential collaborators and employers.
- Evaluate projects and provide feedback: assemble a panel of experts in geodesy, programming, and project evaluation to assess projects based on established criteria. Provide detailed feedback to participants, highlighting strengths, areas for improvement, and potential applications of their projects. Encourage participants to incorporate feedback into their presentations and reflect on their learning experiences.
- Recognize and reward outstanding projects: acknowledge and reward exceptional projects, showcasing the best solutions and inspiring others to pursue their passions in geodesy. Consider various categories for awards, such as technical innovation, creativity, impact potential, and overall presentation. Recognize the contributions of mentors, sponsors, and organizers who played a crucial role in the hackathon's success.
- Share projects online: promote participants' projects through online presentations, websites, or publications, showcasing their work to a global audience. Encourage participants to share their code and data on open-source platforms, contributing to the collective knowledge in geodesy. Leverage social media to amplify the hackathon's impact and attract future participants and collaborators.

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– Foster ongoing engagement: Maintain an online community or platform where participants can continue connecting, sharing, and collaborating. Organize follow-up events, such as networking gatherings or workshops, to maintain connections and provide ongoing support for participants. Encourage further learning and exploration by promoting additional resources, such as online courses, tutorials, and community forums.

5. HACKATHON IDEAS

The topics of the hackathon will very much depend on the level of the participants. Since in our case the level of students was approximately the same and the main thing is that most of them first got acquainted with programming in this very course, the set is only slightly beyond the usual computational tasks. If your situation is a bit more advanced, you can safely complicate the hackathon topics. Generative AI and chat-bots are real helpers for generating ideas. You can encourage students to look for ideas on their own. The following are a few of those ideas:

– Development of an application to convert geographical coordinates into rectangular coordinates and vice versa.
– Creation of a mobile application for measuring distances between two points on a map.
– Develop a programme to determine the optimal location for cellular antenna placement.
– Development of a mobile application for determining coordinates using GNSS.
– Design an app or web platform that allows students to contribute to global geospatial datasets by collecting data through their smartphones or local observations.
– Create a fun and engaging game that teaches players about basic geodetic principles like coordinate systems, map projections, and remote sensing.
– Design a simulation or game that allows students to explore the effects of Earth's rotation on phenomena like day and night, tides, and satellite orbits.
– Guide students through the process of building a simple GNSS receiver using affordable components and open-source software, introducing them to fundamental GNSS principles.
– Challenge students to analyze earthquake data and GPS measurements to visualize and predict the movement of tectonic plates and potential earthquake risks.
– Work with real-time earthquake data from global networks to develop improved algorithms for early warning systems, contributing to earthquake preparedness and disaster mitigation.
– Utilize satellite orbit data and ground gravity measurements to develop new algorithms for refining the global gravity field model, leading to better understanding of Earth's internal structure and mass distribution.

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- Train machine learning models on historical data and current observations to predict regional sea level changes under different climate scenarios, aiding coastal planning and adaptation.

Thus, the ideas are practicaly endless and can and should be tailored to the level of the hackathon participants. From basic algorithms to topics concerning advanced problems in geodesy.

6. CONCLUSION

Hackathons offer a transformative approach to modern geodesy education, providing students with hands-on learning experiences, fostering teamwork, cultivating creativity, and developing critical thinking and problem-solving skills. By immersing students in authentic learning environments, hackathons prepare them for success in an ever-evolving and demanding field. As geodesy continues to advance, hackathons will undoubtedly play a pivotal role in shaping the future of geodesy education and empowering students to become the innovators and leaders of tomorrow.

BIOGRAPHICAL NOTES

Mr. Ilya Oshchepkov was born in 1990. He graduated from the Moscow State University of Geodesy and Cartography (MIIGAiK) in 2011 as a B. Sc. in Geodesy. In 2013, he received a M. Sc. degree in Geodesy and Earth Remote Sensing from the same university. His main research interests are gravimetry, physical and space geodesy, geodetic reference systems and frames. He has been teaching at his alma mater since 2017.

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