Some considerations on the potential impact of Artificial Intelligence for surveyors' work

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SUMMARY

Artificial intelligence (AI) simulates human intellect to enable machines to perform specific tasks better than humans and to emulate human actions. AI can already perform basic tasks without human intervention, store existing data, and produce better results from these data. In the future, advanced AI machines may be able to connect with and better interpret human thoughts. While still very hypothetical, future AI's could be smarter than the human mind in some areas. Surveying is closely linked to technological progress. It is expected that the work of surveyors will continue to be affected by new technologies in the coming years, very much like in previous decades. The contribution starts from the surveyor 2.0 model, which defines the surveyor 2.0 framework: Manage, Measure, Model. The different functions of a surveyor 2.0, such as knowledge manager, land professional, geodesist, information manager, data acquirer, system designer, field officer, quality manager are reviewed to see whether they may be influenced by artificial intelligence in the coming years.

ZUSAMMENFASSUNG

Künstliche Intelligenz (KI) simuliert den menschlichen Intellekt, um Maschinen in die Lage zu versetzen, bestimmte Aufgaben besser zu erfüllen als der Mensch und um menschliche Handlungen nachzuahmen. KI kann bereits einfache Aufgaben ohne menschliches Zutun erledigen, vorhandene Daten speichern und aus diesen Daten bessere Ergebnisse erzeugen. In Zukunft könnten fortgeschrittene KI-Maschinen in der Lage sein, sich mit menschlichen Gedanken zu verbinden und sie besser zu interpretieren. Auch wenn dies noch sehr hypothetisch ist, könnten künftige KI-Maschinen in einigen Bereichen intelligenter sein als der menschliche Verstand. Das Vermessungswesen ist eng mit dem technologischen Fortschritt verbunden. Es ist zu erwarten, dass die Arbeit von Vermessungsingenieuren auch in den kommenden Jahren von neuen Technologien beeinflusst wird, ähnlich wie in den vergangenen Jahrzehnten. Der Beitrag geht von dem Modell Surveyor 2.0 aus, das den Surveyor 2.0 definiert: managen, messen, modellieren. Die verschiedenen Funktionen eines Surveyor 2.0, wie Wissensmanager, Land Professional, Geodät, Informationsmanager, Datenerfasser, Systemdesigner, Außendienstmitarbeiter, Qualitätsmanager werden daraufhin untersucht, ob sie in den kommenden Jahren von künstlicher Intelligenz beeinflusst werden können.

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1. ARTIFICIAL INTELLIGENCE

What is Artificial Intelligence?

Even though artificial intelligence (AI) is the latest buzzword in the industry today, AI has been around for decades. Artificial intelligence is a field that experts have been looking at for a long time.

The first known definition comes from McCarthy et al (1955), who state that ..*every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves*. They then continue *…the artificial intelligence problem is taken to be that of making a machine behave in ways that would be called intelligent if a human were so behaving*. A wide range of applications can be classified as AI under this very general definition. Samoili et al (2021) conducted a qualitative analysis in a set of 38 AI policy and institutional reports, 23 relevant research publications and 3 market reports, from 1955 until 2020. They conclude, that *most definitions found in research, policy or market reports are vague and propose an ideal target rather than a measurable research concept.*

This paper strives to relate the practical work of surveyors to developments in AI. Therefore, a definition that is as technical as possible is preferred. The definition proposed by the European Commission High Level Expert Group on AI (AI HLEG) appears to be the closest match to this preference: *Artificial intelligence (AI) systems are software (and possibly also hardware) systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best action(s) to take to achieve the given goal. AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behaviour by analysing how the environment is affected by their previous actions.* (AI HLEG, 2019).

2. THE FUNCTIONS OF THE SURVEYOR

2.1 The FIG definition

In 2004, the FIG General Assembly adopted its own definition of the functions of the surveyor (FIG, 2004):

A surveyor is a professional person with the academic qualifications and technical expertise to conduct one, or more, of the following activities;

• to determine, measure and represent land, three-dimensional objects, point-fields and trajectories;

• to assemble and interpret land and geographically related information,

• to use that information for the planning and efficient administration of the land, the sea and any structures thereon; and,

• to conduct research into the above practices and to develop them.

2.2 Surveyor 2.0

At the FIG Working Week in Rome, Italy, (May 6-10, 2012) FIG started to broaden its view towards a wider definition, described by the term 'Surveyor 2.0' (Schennach et al., 2012). Teo CheeHai, then president of FIG, has noticed that '*the role of the surveyor is evolving from a professional who used to be viewed as a "measurer" to a professional who measures, models, and manages'.* In an interview (ACSM, 2012) the then president argues, that surveyors *'will be required to embrace open standards; be inclusive, learn to incorporate volunteered information; ensure interoperability of systems, institutions and legislation; have a culture of collaboration and sharing to avoid duplication; develop enabling platforms in order to deliver knowledge derived from data of different scales and origins in the form of "actionable" information'.*

In an ongoing discussion FIG now promotes the 'Surveyor 2.0 model' (Fig. 1). Here, the surveyor is described in the triad Manage-Model-Measure (see also Müller, 2016).

The following section offers some reflections on the extent to which the various functions may be affected by the influence of Artificial Intelligence AI.

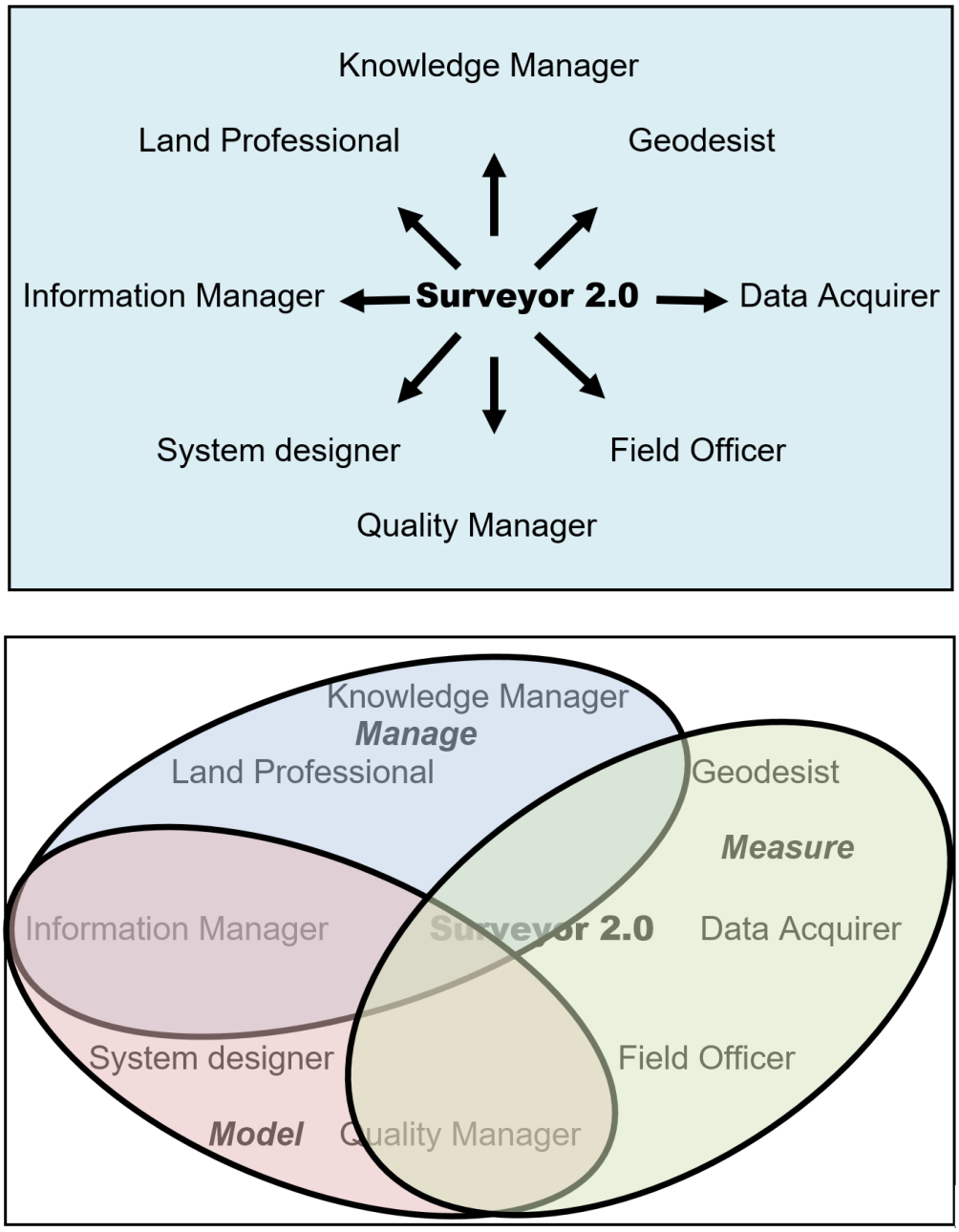

Figure 1. The Surveyor 2.0 Model,
adapted from G. Schennach et al. (2012)

3. INFLUENCE OF ARTIFICIAL INTELLIGENCE AI ON THE FUNCTIONS OF THE SURVEYOR

The following discussion refers to all functions listed in Fig. 1.

Knowledge Manager

Knowledge Management requires an understanding of how knowledge is created, while AI provides the capabilities to expand, use, and create knowledge in new ways. Self-learning artificial neural networks provide text/data mining, pattern recognition and natural language processing to mimic the way the human brain works. Hence, AI and Knowledge Management can be seen as two sides of the same coin (Rhem, 2017).

Land Professional

One can imagine a scenario where software is available to identify facts and data patterns and produce an analysis that can be used to recommend a business strategy or decision. Bell (2018) asks *How long will it be until we see AI software available to purchase and apply to proprietary data located in lease and contract systems and to digital land documents that allows machine learning to draw conclusions and make recommendations based on all data available to it?* Nobody knows. It is safe to assume that this is still years away. However, it seems likely that some form of AI software to help Land Professionals analyze data faster and more efficiently is already on the way.

Geodesist

Classical geodetic data analysis often requires strong prior assumptions regarding problem specification and underlying probability distributions. Machine learning methods are more flexible with respect to the assumed properties of the input and the form of the desired outputs Common ground between geodetic data analysis and machine learning can be found in applications such as optimal estimation, signal separation, hazard estimation, and measurement strategy design (Butt et al, 2021).

Information Manager

Advanced information management systems enable streamlining and automation of mostly repetitive document-based procedures. Artificial neural networks can quickly search vast amounts of information. Raw data is often still processed manually. AI can significantly improve autonomous processing of disorganized or unstructured information. In managing unstructured data, AI typically follows two steps. classification and contextualization. For diverse information, various machine learning classifiers are used. These classifiers are self-learning, learn from experience, and automatically classify data into other groups. A number of AI techniques are also available for contextualization (Yadav, 2021).

Data Acquirer

Data acquisition is the process of taking measurements of real-world physical phenomena using signals and digitizing them so that a computer and software can modify them. Among the many examples of AI being used for data acquisition is the national mapping agency of Finland. The National Land Survey of Finland has implemented deep learning solutions for detecting objects and their changes, for buildings, roads and watercourses (Zhu et al, 2023). This project has once again proven that deep learning technology is one of the best solutions for reducing the labour-intensive tasks involved in updating topographic maps.

System Designer

Reflecting on AI in system design quickly comes down to the question, whether or not an AI system can be creative (Daucot, 2018**).** If an AI system is capable of linking data to create meaning, could it use that meaning to design creative solutions to problems? So if an AI system could technically "create" something, could it also "design" something without human guidance? For the designer, it comes down to providing valid inputs to the AI system. For the AI system, it's about making the most of the inputs and producing the best output. It still seems quite unclear how exactly AI support for system design might look like in practical terms.

Field Officer

If we decide to closely link this field with field data acquisition tasks, robots and autonomous technology will affect surveying roles (Coleman, 2021). For decades, surveyors have used advanced technology to boost productivity in the field. For example, robotic total stations have long enabled an operator to perform a site survey alone, thanks to automated rotation and tracking of the prism. New robots have an ever-increasingly level of autonomy that will not only require automation of workflows, but will also change the face of the workflows themselves.

Quality Manager

Data quality management tools use AI and machine learning ML in several different ways (Reno, 2022). Because ML learns over time, it is very useful for monitoring and improving data quality. Specifically, data quality management can use ML models to learn from large amounts of data, automatically process non-standard data to conform to specific formats or standards, and develop and create new data quality rules as data evolves. ML and AI technologies work together to identify data errors potentially without human oversight. An ML/AI-driven solution is also able to establish new data quality rules and perform sophisticated validation checks, all without manual intervention. ML/AI-based systems can reduce errors, identify duplicate data, fill in missing data, and validate data accuracy.

4. CONCLUSIONS

Artificial Intelligence AI is on its way to establish itself as a disruptive force within the geospatial domain. Although pure Artificial Intelligence is still in the research stage, it is already obvious that AI systems need to be built by a diverse team. Given that Artificial Intelligence, statistical and geospatial know how are coming together rapidly and being promoted as the next 'big thing' to enable evidence-based decision making and policy delivery, it is crucial that diversity is high on the technology agenda. Surveyors should embrace the opportunity to be an integral part of the diverse team. The intent of AI is to enable computers to perform tasks that normally require human intelligence. AI will therefore evolve to take jobs once performed by humans. Given the diverse skills and competencies of a Surveyor 2.0, the risk is considered low that the surveying profession in this sense will be threatened by AI. Rather, a Surveyor 2.0 will be able to expand his or her opportunities through the intelligent use of AI.

REFERENCES

ACSM, 2012. FIG looks to surveyor 2.0, ACSM Bulletin June 2012, pp 31-32. http://www.multibriefs.com/briefs/nsps/~ acsm257p31.pdf .

AI HLEG (2019). A definition of AI: Main capabilities and disciplines. Independent High-Level Expert Group on Artificial Intelligence, set up by the European Commission, https://digital-strategy.ec.europa.eu/en/policies/expert-group-ai

Bell, M. (2018). Will Artifcial Intelligence Transform the Land Profession? https://www.landman.org/news-and-blog/will-artificial-intelligence-transform-the-land-profession

Butt, J., Wieser, A., Gojcic, Z. & Zhou, C. (2021). Machine learning and geodesy: A survey. Journal of Applied Geodesy, 15(2), 117-133. https://doi.org/10.1515/jag-2020-0043

Coleman, J. (2021). Integrating Robotics into the Construction Surveyor's Workflow. GIM International. https://www.gim-international.com/content/article/integrating-robotics-into-the-construction-surveyor-s-workflow

Daucot, N. (2018). Can an A.I. system be a designer? https://medium.com/@nickdauchot/can-a-i-be-used-to-design-317ed3d71e87

FIG (2004). FIG Definition of the functions of the surveyor https://www.fig.net/about/general/definition/definition.pdf.

McCarthy, J., Minsky, M. L., Rochester, N., Shannon, C.E. (1955). A Proposal For The Dartmouth Summer Research Project On Artificial Intelligence.

Müller, H. (2016). Bridging the gap between surveyors and the geo-spatial society, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLI-B4, 683-686, doi:10.5194/isprs-archives-XLI-B4-683-2016, 2016.

Reno, G. (2022). The Role of ML and AI in Data Quality Management. https://firsteigen.com/blog/the-role-of-ml-and-ai-in-data-quality-management/

Rhem, A, (2017). The Connection between Artificial Intelligence and Knowledge Management. https://www.kminstitute.org/blog/connection-between-artificial-intelligence-and-knowledge-management.

Samoili, S., López Cobo, M., Delipetrev, B., Martínez-Plumed, F., Gómez, E., and De Prato, G. (2021). AI Watch, Defining Artificial Intelligence 2.0, Towards an operational definition

and taxonomy for the AI landscape, EUR 30873 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42648-6, doi:10.2760/019901, JRC126426.

Schennach, G., Lemmen, C., Villikka, M (2012). Be part of the solution, not the problem! FIG Working Week, Rome, Italy. GIM International, July 2012, pp 33-35. https://www.fig.net/resources/articles_about_fig/gim-international/2012_07_gim_report.pdf.

Yadav, U. (2021). AI techniques in Information Management, Insights2Techinfo, pp. 1. https://insights2techinfo.com/ai-techniques-in-information-management/

Zhu, L, Raninen, J., Hattula, E. (2023). How the National Land Survey of Finland is exploring AI technology. GIM International. https://www.gim-international.com/content/article/how-the-national-land-survey-of-finland-is-exploring-ai-technology.

BIOGRAPHICAL NOTES

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