GHENT UNIVERSITY

Course Specifications

Valid in the academic year 2024-2025

Geospatial Artificial Intelligence (C004538)

Course size *(nominal values; actual values may depend on programme)*

Credits 5.0 **Study time 150 h**

Course offerings in academic year 2024-2025

A (semester 2)	English	Gent

Lecturers in academic year 2024-2025

Van de Weghe, Nico	WE12	lecturer-in-charge
Huang, Haosheng	WE12	co-lecturer
Van de Voorde, Tim	WE12	co-lecturer

Offered in the following programmes in 2024-2025	crdts	offering
Master of Science in Teaching in Science and Technology(main subject Geography and Geomatics)	5	A
Master of Science in Geography and Geomatics	5	A
Exchange programme in Geography and Geomatics (master's level)	5	A

Teaching languages

English

Keywords

Artificial Intelligence (AI), Geospatial Analysis, Neural Networks (ANNs, CNNs, RNNs), Machine Learning (ML), Large Language Models (LLMs), Data Processing and Ethics

Position of the course

In this course, students will delve into the fascinating integration of artificial intelligence (AI) within the field of geography. The course not only provides a comprehensive overview of the principles and concepts behind AI, but also enables students to gain practical experience through interactive applications with various AI technologies and algorithms. Moreover, they will learn how these advanced tools can be used to identify, analyze, and address complex geographical issues and challenges

Contents

1 Overview and Introduction
* Overview of AI and its sub-domains
* Unsupervised & Supervised Learning | Traditional ML methods
* Example use cases of AI in the geospatial domain
* Ethical issues: bias and fairness

2 Ontology (knowledge representation) and qualitative spatial reasoning
* Ontology
* Semantic web and linked Data
* Knowledge Graphs
* Qualitative Spatial Reasoning
* Hands-on: Python for (spatial) data cleaning, processing, and transformation

3 Foundations of Artificial Neural Networks (ANNs)
* Basic neural network architecture
* Fitting a function with Stochastic Gradient Descent
* How a neural network approximates any function
* Multi-Layer Perceptron implementation

* Hands-on tutorials in Python & PyTorch

4 Deep learning – Convolutional Neural Networks (CNNs)
* Computer vision problems in geography
* Feature learning versus feature engineering
* Convolutions, strides & padding, understanding convolution equations
* Hands-on training and implementation of a CNN on remote sensing data using fast.ai and PyTorch

5 Deep learning – Recurrent Neural Networks (RNNs)
* RNNs (LSTM, GRU, Transformers) walk-through (basic ideas + hands-on tutorials)
* Applications of RNNs for geospatial applications: traffic prediction, next-location prediction
* Hands-on tutorials in Python

6 Generative Adversarial Network (GAN) and Reinforcement Learning

7 Introduction to NLP, LLM, "GenAI", Hybrid-AI

8 Project work with intermediate feedback

Initial competences

Experience in Python programming and in handling geospatial data.

Final competences

1 Understand the fundamentals of GeoAI and its main techniques and algorithms.
2 Gain hands-on experience in various AI techniques and algorithms relevant to geospatial analysis using the Python programming language.
3 Apply AI techniques to address or solve (simple) geographical problems and issues.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Seminar, Lecture, Independent work

Extra information on the teaching methods

Interactive lectures and guided hands-on sessions for which students use their laptops.
Use of Artificial Intelligence (AI)
With the rise of sophisticated AI tools, it's evident that their integration into GIS applications is
becoming increasingly inevitable. This course recognizes the potential of AI, including Large Language
Models (LLMs) like Generative Pre-Trained Transformer (GPT) variants and other platforms such as
Perplexity, Google Bard, and numerous other tools and plugins. Students are encouraged to explore
and utilize these AI tools if they want to. However, in doing so, we ask for two simple acts of
transparency: (1) indicate when and where an AI tool has been employed in your GIS assignment and
(2) specify which tool or platform you've used (e.g., GPT-3.5, GPT-4, GPT-4 Advanced Data Analysis,
certain plugins, etc.). Think of this as giving credit, similar to citing a helpful post from Stack Overflow
or gis.stackexchange.com. By being transparent, you're not only upholding academic integrity but also
paving the way for deeper discussions on the exciting confluence of GIS and AI. Furthermore, in our
exploration of GIScience and the role of AI tools, we draw inspiration from our

university's mantra:
"Durf Denken" or "Dare to Think". We urge you all to not only "Dare to Think" but also to "Dare to
Question Further" ("Durf Doorvragen"). While AI opens new horizons, it's essential to be tenacious in
our understanding of its insights. Be critical and persistent and keep on prompting until you get a
satisfying, correct, and clear answer.

Study material

Type: Slides

Name: Slides and Jupyter notebooks'
Indicative price: Free or paid by faculty
Optional: no
Additional information: Slides and Jupyter notebooks used during the lectures will be made available on Ufora together with additional learning materials (background information, links to relevant websites, online tutorials, and videos). Students will need a (free) Google account for some exercis.

References

- Duckham, M., Sun,Q., Worboys, M.F., GIS a Computing Perspective – Chapter 9: Artificial Intelligence and GIS, 3rd edition, CRC press, 2023

- Howard, J. & Gugger, S., Deep Learning for Coders with fast.ai and Pytorch: AI Applications without a PhD, 1st edition, O'Reilly, 2020

Course content-related study coaching

Coaching by AAP and via Ufora and MS Teams

Assessment moments

end-of-term and continuous assessment

Examination methods in case of periodic assessment during the first examination period

Oral assessment, Written assessment with open-ended questions

Examination methods in case of periodic assessment during the second examination period

Oral assessment, Written assessment with open-ended questions

Examination methods in case of permanent assessment

Assignment

Possibilities of retake in case of permanent assessment

examination during the second examination period is possible in modified form

Calculation of the examination mark

Periodical [50%]
Non-periodical evaluation (course project) [50%]

To pass the course component or to obtain a deliberable grade, the student must have achieved an equivalent score of 50% on each part of the evaluation (theory + project work).