

Development of an AI-Powered Digital Twin for Dynamic Analysis of Drawing Tests: Exploring Fatigue and Educational Influences

Summary

This position focuses on leveraging AI-based methods to enhance the analysis of drawing tests for assessing fine motor skills and cognitive function, with applications in medical fields. The project aims to develop AI-powered digital twins capable of generating synthetic data mimicking human drawing behavior under varying levels of fatigue and cognitive development. Additionally, it seeks to develop twins for analyzing drawing tests to support differential diagnosis. Responsibilities include publishing results in top-tier journals, supporting teaching activities, and co-supervising students. Requirements include a Master's degree in relevant fields, proficiency in programming, strong analytical skills, and a demonstrated interest in the research topic.

Research field:	Information and communication technology
Supervisors:	Dr. Sven Nömm Aaro Toomela
Availability:	This position is available.
Offered by:	School of Information Technologies Department of Software Science
Application deadline:	Applications are accepted between January 01, 2025 00:00 and January 24, 2025 23:59 (Europe/Zurich)

Description

Drawing tests, such as the spiral drawing test, serve as invaluable tools for assessing fine motor skills and cognitive function, with applications in various medical fields. In recent years, AI-based methods developed for motion acquisition and analysis have demonstrated sophisticated results and begun to attract interest from neighboring fields, such as fatigue detection and monitoring cognitive processes. This underscores the importance of investigating how cognitive processes interact with factors like fatigue and cognitive development to develop personalized interventions and diagnostic tools. Simultaneously, realizing the full potential of AI-based technologies requires large datasets to train the models. While simple data augmentation techniques may address the issue locally [1,2], a more generic approach is needed to relate fatigue and cognitive conditions [3,4]. The proposed project envisions a two-component AI-powered digital twin as the solution. The first component aims to mimic human drawing behavior as a function of fatigue level and stage of cognitive development, while the second component focuses on analyzing drawing tests in relation to known levels of cognitive development and fatigue.

Research Objectives:

- Investigate the limitations of the data augmentation using generative adversarial networks and offline generative AI tools.
- Develop an AI-powered digital twin for synthetic data generation capable of producing drawings for specific test types (e.g., spiral, Luria, etc.) at given levels of fatigue and cognitive development.
- Develop an AI-powered digital twin for the analysis of drawing tests with the ability to support differential diagnosis.
- Investigate the differences and applicability of the twins across various application areas.

Responsibilities:

- Publish achieved results in (Q1) journals.
- Support teaching activities of the supervisor by assisting with practice lessons.
- Co-supervise bachelor and master-level students.

Requirements:

- Master's degree or equivalent in Computer Science, Psychology, Neuroscience, or a related field.

- Clear interest in the research topic, demonstrated through a motivation letter and research plan.
- Proficiency in Python, MATLAB, and R programming.
- Excellent English communication skills, both written and verbal.
- Strong analytical and research abilities.
- Capacity to work independently and collaboratively in an international team.
- Preferred: Experience in programming and deep learning, showcased through GitHub projects.
- Applicants are encouraged to submit preliminary research plan.

Supervisors: Prof. Sven Nõmm; Prof. Aaro Toomela (Tallinn University)

References:

- [1] Deep CNN based classification of the archimedes spiral drawing tests to support diagnostics of the Parkinson's disease. Sven Nõmm, Sergei Zarembo, Kadri Medijainen, Pille Taba, Aaro Toomela, IFAC-PapersOnLine
- [2] CNN based analysis of the Luria's alternating series test for Parkinson's disease diagnostics. Sergei Zarembo, Sven Nõmm, Kadri Medijainen, Pille Taba, Aaro Toomela. - Recent Challenges in Intelligent Information and Database Systems: 13th Asian Conference, ACIIDS 2021, Phuket, Thailand, April 7–10, 2021, Proceedings 13
- [3] Generative Adversarial Networks as a Data Augmentation Tool for CNN-Based Parkinson's Disease Diagnostics E Dzotsenidze, E Valla, S Nõmm, K Medijainen, P Taba... - IFAC-PapersOnLine, 2022
- [4] Comparison of one-two-and three-dimensional CNN models for drawing-test-based diagnostics of the Parkinson's disease X Wang, J Huang, M Chatzakou, S Nõmm, E Valla... - Biomedical Signal Processing and Control, 2024



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