Rev. 11/12/2023

**Specifications of Bachelor of Science project for students at**

**Aarhus University, Department of Electrical and Computer Engineering**

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| **Date** |  | | |
| **Project title** | **Bridging the Gap:** Integrating Linear Algebra in the Development and Understanding of Large Language Models for Software Engineering Applications. | | |
| **The project applies to students with a specialisation in** (mark with X) | | | |
| Electrical Engineering |  | Computer Engineering | x |
| **ECE supervisor (co-supervisor) info** including name, email, mobile phone.  *Note - main supervisor must be ECE VIP, Assistant Prof or more senior. PhD students, Postdocs and other experts (e.g. from industry, or from a different AU department) can co-supervise.* | Hugo Daniel Macedo (Main supervisor)  [hdm@ece.au.dk](mailto:hdm@ece.au.dk)  + 45  Martin Knudsen (Co-supervisor)  [makn@ece.au.dk](mailto:makn@ece.au.dk)  +45 25 85 25 24 | | |
| **Special demands to:**  - equipment  - place  - confidentiality |  | | |

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| **Project description** |
| * **Background/Motivations**   Large Language Models (LLMs) like GPT-4 have revolutionized natural language processing with their advanced text generation and problem-solving skills. These models rely heavily on linear algebra to navigate the complex vector spaces they work in.  Despite the growing use of AI in software engineering, there's still a notable disconnect between the core mathematical principles and their practical use in software development. Linear algebra, while fundamental to LLMs, is often not directly linked to its real-world applications for software engineers. This thesis aims to bridge this gap by delving into the synergy between LLMs, mathematics, and software engineering, with a focus on practical linear algebra education.   * **Objectives** * **Theoretical Exploration:** Delve into the mathematics behind LLMs, focusing on the linear algebraic operations that underpin e.g. neural network architectures, weight optimization, and data representation. * **Educational Synergy:** Craft a curricular component that correlates linear algebra principles with the practical aspects of LLM structures and algorithms, thus bridging the gap between abstract mathematical concepts and their practical applications in AI. * **Software Engineering Application:** Implement a chatbot … * **Evaluation:** Assess the effectiveness of compression of LLM (Flan-T5-Base) with low rank decomposition of attention weight matrices. * **Learning outcomes** * What is the linear algebra background used when implementing the LLMs. (What are the linear algebra operations that support Deep Learning) * Develop a deep understanding of LLM’s, their structure, and functioning. * Acquire hands-on experience in working with LLM’s and applying them to real-world language processing tasks. |