The overview of Artificial Intelligence for SMEs-based Software Engineering in Satakunta region

1. Industry-academic collaboration-based software engineering (SE)

In the rapidly evolving field of software engineering, the collaboration between industry and academia has emerged as a vital mechanism for driving innovation, enhancing educational experiences, and addressing real-world challenges. Industry-academic collaborations integrate the theoretical and empirical research strengths of academic institutions with the practical, application-oriented expertise of industry partners. This synergy fosters the development of cutting-edge technologies, methodologies, and tools that can effectively address the complex and dynamic demands of modern software systems.

Such collaborations are mutually beneficial. Academic researchers gain access to real-world data, case studies, and industry-specific problems, which enrich their research and provide students with practical learning opportunities. Conversely, industry partners benefit from the fresh perspectives, innovative solutions, and advanced research capabilities available in academic institutions. This partnership not only accelerates the research and development cycle but also ensures that the educational curriculum remains relevant and aligned with current industry needs. Key areas of focus in industry-academic collaboration include:

1) Joint Research Projects: Collaborative research initiatives aimed at solving specific technical problems or exploring new areas of technology. The details of joint research projects are following:
    - Description: Collaborative research to solve specific technical problems.
    - Benefits to Academia: Access to real-world data and industry-specific problems.
    - Benefits to Industry: Fresh perspectives and innovative solutions.
    - Source: Liaison Office for University-Industry Collaboration, University of Tokyo. "Collaborative Research Programs." (Lee K.J., et al., 2010)
2) Internship and Co-op Programs: Providing students with hands-on experience in industry settings, enhancing their practical skills and employability. The details of internship and co-op programs are following:
    - Description: Hands-on experience for students in industry settings.
    - Benefits to Academia: Enhanced practical skills and employability for students.
    - Benefits to Industry: Well-prepared workforce with practical experience.
    - Source: National Academies of Sciences, Engineering, and Medicine. "Enhancing the Effectiveness of Team Science." (Hilton M.L. and Cooke N.J. 2015)
3) Technology Transfer and Commercialization: Facilitating the movement of new technologies from academic research labs to commercial applications. The details of technology transfer and commercialization are following:
    - Description: Movement of technologies from academic labs to commercial applications.
    - Benefits to Academia: Commercialization of research outputs.
    - Benefits to Industry: Access to cutting-edge technologies.
    - Source: Association of University Technology Managers (AUTM). "Technology Transfer Overview." (Fleischut P.M. and Haas S., 2005)
4) Professional Development: Focusing on practical applications of AI in business, helping professionals understand and implement AI technologies effectively. The details of professional development are following:
    - Description: Among the programs listed, the AI-TIE Program (AI Technology Innovation Ecosystems for Competitiveness of SMEs) has significant components focused on professional development. These initiatives provide tailored support for SMEs and foster collaboration with academic institutions, making them key contributors to professional growth in AI.
    - Benefits to Academia: i) industry-Relevant Research as collaboration with SMEs provides data and real-world problems for academic research, ii) enhanced Curriculum: Academic institutions receive feedback from industry, ensuring their programs remain practical and aligned with market needs, and iii) increased Funding Opportunities: Partnerships often come with funding for joint projects and research.

- Benefits to Industry: i) workforce Skill Enhancement: SME employees gain AI-related expertise, boosting organizational capabilities, ii) tailored Business Solutions: practical training helps SMEs adopt AI solutions to address specific business challenges, iii) improved competitiveness: employees' improved skills help SMEs innovate and maintain a competitive edge.
- Source: Haaga-Helia. "Empowering SMEs with Artificial Interlligence" (Anna L. and Iris H., 2023)

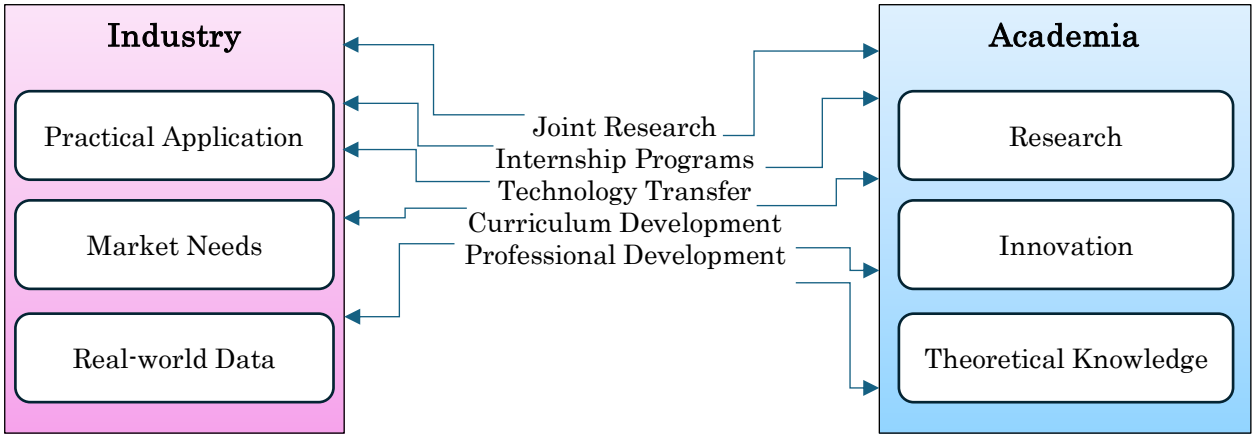

Fig 1. The diagram illustrates how these collaborations bring together the strengths of both sectors

The successful implementation of industry-academic collaborations in software engineering requires careful planning, clear communication, and a shared vision. It involves navigating challenges such as intellectual property rights, aligning objectives, and managing different organizational cultures. However, when executed effectively, these collaborations can lead to significant advancements in software engineering, contributing to economic growth, technological progress, and the preparation of a highly skilled workforce.

A table summarizing the key aspects and benefits of industry-academic collaboration in software engineering, and a diagram visually representing the collaboration areas between academia and industry. The table outlines different types of collaborations, their descriptions, and the respective benefits for both academia and industry. The diagram illustrates how these collaborations bring together the strengths of both sectors.

Table 1. The key aspects and benefits of industry-academic collaboration in software engineering.

Collaboration type / Case study	Description	Benefits		Reference
Joint Research		**Industry**	**Academia**	
Enhancing Software Requirements Engineering with CASCRE	This research focuses on improving software requirements engineering (RE) by integrating agent-oriented RE (AORE) and service-oriented RE (SORE) methodologies into a hybrid framework called CASCRE. The aim is to enhance RE processes by leveraging the strengths of both paradigms and incorporating crowd-based information from social media platforms. The framework addresses challenges such as gathering adequate requirements, aligning business requirements with software products, prioritizing requirements, and recommending innovative ideas. The empirical research involved expert groups from academia and industry, validating CASCRE's effectiveness compared to AORE and SORE independently.	-*Innovative Solutions and Fresh Perspectives:* Industry partners benefited from innovative approaches and fresh perspectives brought by academic researchers. CASCRE's integration of agent and service paradigms demonstrated significant improvements in RE processes. -*Improved Software Development Practices:* The CASCRE framework led to better quality software with improved alignment to business needs, reducing the likelihood of project failure due to poor requirements management. -*Access to Cutting-Edge Research:* Industry partners gained access to the latest research and technological advancements, which could be directly applied to their projects, fostering innovation and efficiency.	-*Access to Real-World Data and Challenges:* The research provided academic participants with real-world data and practical challenges in RE, enriching their research and offering empirical validation of theoretical models. -*Enhanced Educational Experiences:* Collaboration with industry offered students and researchers practical insights and hands-on experience, improving their skills and employability. -*Empirical Research Opportunities:* The project allowed academic researchers to apply empirical research methodologies in real-world settings, advancing the field with validated, practical insights.	Sinkie, M., Gronli, T. M., Midekso, D., and Lakhan, A. 2023. Joint Impact of Agents and Services in Enhancing Software Requirements Engineering. Electronics, 12(18), 3955.
MEDICOR Africa Pharmaceuticals and Medical Supplies PLC	MEDICOR Africa, a pharmaceutical company in Ethiopia, collaborated with a software development company to integrate its system with major hospital systems. The goal was to track drug demand, prevent wastage, and address counterfeit drug issues by providing genuine expiration dates to customers via a mobile application. The project applied the CASCRE framework to gather and prioritize requirements efficiently.	-*Enhanced Requirements Management:* The CASCRE framework helped in accurately gathering and prioritizing requirements, leading to a better-aligned and more reliable software system. -*Improved Operational Efficiency:* By integrating with hospital systems and tracking drug demand accurately, MEDICOR Africa could prevent drug wastage and address counterfeit issues more effectively.	-*Practical Application of Theories:* The case study provided a practical application of the CASCRE framework, validating its effectiveness in a real-world scenario. -*Research and Development*: Academic researchers could observe and analyze the practical challenges and outcomes of implementing the framework in an industry setting.	Sinkie, M., Gronli, T. M., Midekso, D., and Lakhan, A. 2023. Joint Impact of Agents and Services in Enhancing Software Requirements Engineering. Electronics, 12(18), 3955.

Internship and Co-op Programs					
	Certus Model in Software Engineering: Bridging Academia and Industry	The Certus Model is a structured approach to industry-academia collaboration in software engineering, developed through an eight-year collaborative research project. It focuses on participative knowledge generation between industry and academia, including clear roles, principles of interaction, and strategies for maintaining continuous commitment and alignment. The model integrates context-driven research and industry champions to ensure relevance and impact.	*Enhanced Innovation Capacity:* Companies gain access to cutting-edge research and innovative solutions tailored to their specific needs, improving their competitive edge. *Risk Mitigation*: Collaborative projects allow for the sharing of resources and risks associated with research and development. *Talent Pipeline:* Collaboration with academia provides companies with early access to skilled graduates, aiding in talent acquisition and retention..	*Practical Application of Research:* Academic researchers can apply their theoretical models to real-world problems, validating and refining their work. *Funding and Resources:* Partnerships with industry provide additional funding and resources, enhancing research capabilities and facilities. *Enhanced Curriculum:* Industry feedback helps in updating academic programs to ensure they are aligned with current industry needs, improving the employability of graduates.	Marijan, D., and Gotlieb, A. 2021. Industry-Academia research collaboration in software engineering: The Certus model. Information and software technology, 132, 106473.
Technology Transfer and Commercialization					
	Technology Transfer and Commercialization at Michigan State University	Michigan State University (MSU) dedicated to technology transfer to benefit farming communities and society through research results and innovations. MSU transfers technology through two primary methods: the Extension Service and Intellectual Property Rights (IPR)-led technology transfer facilitated by MSU Technologies. The university manages its intellectual property and technology transfer through MSU Technologies, which provides services such as acquiring, protecting, and licensing IP.	*Access to Cutting-Edge Research:* Industry partners gain access to the latest research and innovations developed at MSU, which can be commercialized to enhance their product offerings and competitiveness. *Innovation and Product Development:* Companies benefit from the advanced technologies and innovations resulting from MSU's research, enabling them to develop new products and improve existing ones. *Risk Mitigation:* Licensing technologies from MSU allows companies to mitigate the risks associated with in-house research and development, as they can leverage proven technologies. *Economic Growth:* The commercialization of MSU	*Commercialization of Research:* MSU benefits from the commercialization of its research through licensing agreements, which provide financial returns in the form of royalties and enhance the practical impact of academic research. *Practical Application of Knowledge:* The transfer of technology allows MSU to see its theoretical research applied in real-world settings, validating and potentially inspiring further academic inquiries. *Strengthened Industry Relationships:* Collaborations with industry enhance MSU's reputation, attract additional funding for future research, and provide valuable feedback to shape academic programs to better meet industry needs.	Maredia, K., Rakhmatov, C., & Herlache, T. (2013). Technology transfer and commercialization policies and practices at Michigan State University. Technology transfer and commercialization: Experiences of India and USA, 136.

			technologies contributes to regional and national economic growth by fostering new businesses and enhancing existing ones.	*Support for Start-Ups:* MSU supports the creation of start-ups based on university technologies, fostering innovation and entrepreneurship among faculty and students.	
Curriculum Development					
	Nokia Learning Center and University of Jyväskylä Collaboration	This case study explores the collaboration between the Nokia Learning Center in China and the University of Jyväskylä in Finland. The partnership aimed to enhance continuing professional development for Nokia's R&D engineers through a one-year web-based university course. The course, designed by the University of Jyväskylä, covered various aspects of adult education and human resources development, integrating theoretical knowledge with practical HRD challenges. The course involved 17 participants from different cultural backgrounds, fostering cross-cultural, technology-mediated learning.	*Enhanced Employee Skills:* Nokia benefited from its employees gaining advanced HRD knowledge and skills,which improved their performance and motivation. *Retention and Loyalty:* Supporting employees' education helped increase their commitment to the company, reducing turnover rates. *Cross-Cultural Competence:* The program promoted cross-cultural understanding and collaboration, essential for a multinational company like Nokia. *Innovative Solutions:* Employees applied new knowledge and innovative HRD practices, contributing to the company's overall strategic goals and operational efficiency.	*Practical Application of Theories:* The University of Jyväskylä could test and refine its educational theories in a real-world setting, enhancing the relevance and impact of its research. *Feedback for Curriculum Development:* The collaboration provided valuable insights into industry needs, helping the university tailor its programs to better prepare students for professional challenges. *Strengthened Industry Relationships:* Building strong ties with Nokia and other industry partners enhanced the university's reputation and opened doors for future collaborations. *Research Opportunities:* The project offered rich data for research on adult education, cross-cultural learning, and the integration of theory and practice in professional development.	Slotte, V., and Tynjälä, P. (2003). Industry–university collaboration for continuing professional development. Journal of education and work, 16(4), 445-464.
Professional Development					
	Increasing the Impact of Industry–Academia Collaboration through Co-Production	This case study explores the co-production model of industry-academia collaboration, focusing on six research project cases conducted over five years in Sweden. The projects involved universities and global companies in the automotive	*Enhanced Innovation:* Companies benefit from access to cutting-edge research and innovative solutions tailored to their specific needs, improving their competitive edge and operational efficiency.	*Commercialization of Research:* Universities benefit from the practical application and commercialization of their research, which can provide financial returns and enhance the societal impact of academic work.	Sannö, A., Öberg, A. E., Flores-Garcia, E., and Jackson, M. (2019). Increasing the impact of industry–academia collaboration through co-production.

		and pharmaceutical industries. The study highlights how co-production can enhance the impact of research by involving both academic and industrial perspectives in the research process. It emphasizes the importance of managing phases such as problem formulation, methodology, and results to achieve successful collaboration and impact.	*Risk Mitigation:* Collaborative projects share resources and risks associated with research and development, reducing the burden on individual companies. *Talent Pipeline*: Companies gain early access to skilled graduates and doctoral students, aiding in talent acquisition and retention. *Practical Solutions:* Industry partners receive actionable and practical solutions to their problems, often leading to improved processes and new product developments.	*Enhanced Curriculum:* Collaboration with industry provides valuable feedback that helps shape academic programs to better meet current industry needs and trends. Research Opportunities: Academic researchers gain access to real-world data and practical challenges that inspire new research directions and collaborative projects. *Strengthened Relationships:* Building strong ties with industry enhances the university's reputation and attracts additional funding for future research.	Technology Innovation Management Review, 9(4).

In conclusion, industry-academic collaborations in software engineering represent a strategic partnership that leverages the strengths of both sectors to drive innovation and address complex challenges. As the field continues to evolve, fostering these collaborations will be crucial for staying at the forefront of technological advancements and preparing the next generation of software engineers.

2. Situation of industry-academic collaboration-based SE for the small and medium sized enterprises (SMEs)

The industry-academic collaboration in software engineering has promising and functioning in the larger company mainly.

2.1 Overview of the industry-academic collaboration-based SE in part of SMEs

Industry-academic collaborations in software engineering for SMEs aim to bridge the gap between theoretical research and practical application. These partnerships enhance innovation and competitiveness by leveraging academic expertise to solve real-world problems faced by SMEs. Key benefits include access to cutting-edge research, cost-effective R&D, a skilled talent pool, and customized technological solutions. Academics benefit through practical application of theories, enhanced research funding, industry-relevant curricula, and increased research impact. Successful collaborations lead to mutual growth and technological advancement for both SMEs and academic institutions. SMEs can leverage industry-academic collaborations to enhance their technological capabilities, reduce costs, access skilled talent, and drive innovation for example.

2.1.1 Access to Cutting-Edge Research and Technologies

Example: An SME in the cybersecurity sector collaborates with a university to develop advanced encryption algorithms, gaining access to the latest research which significantly enhances their product offerings and market competitiveness (NCUB, 2014).

2.1.2 Cost-Effective R&D

Example: A small biotech firm partners with a university to conduct research on new drug formulations. The collaboration allows the SME to undertake extensive R&D without bearing the full cost, leveraging university resources and expertise (Besednjak V.T. et al., 2023).

2.1.3 Skilled Talent Pool

Example: A software development SME collaborates with a technical university, providing internship opportunities for students. This not only helps the company address immediate workforce needs but also serves as a pipeline for recruiting highly skilled future employees (Awasthy R. et al., 2020).

2.1.4 Customized Solutions

Example: An SME in the manufacturing industry partners with an engineering school to develop bespoke automation solutions. The academic researchers tailor their theoretical knowledge to solve specific operational challenges, resulting in increased efficiency and reduced production costs.

2.1.5 Enhanced Innovation Capacity (Kettunen P. et a., 2022).

Example: An agricultural technology SME collaborates with a university to implement machine learning techniques for crop monitoring. This partnership drives innovation, allowing the SME to offer state-of-the-art solutions that significantly improve crop yield predictions and resource management (Kettunen P. et a., 2022).

2.2 Overview of the industry-academic collaboration-based SE in Satakunta region

The collaboration between SMEs and academic institutions in the Satakunta region has been a key driver of regional development and innovation. Historically, these partnerships began modestly with local universities and polytechnics offering support to small businesses through student projects and internships. These early efforts laid the groundwork for more structured and impactful collaborations. There are 3 key milestones as Knowledge Transfer Partnerships, Regional Innovation Programs, and EU-Funded Projects.

Knowledge Transfer Partnerships (KTPs): Initiated in the early 2000s, KTPs have been instrumental in formalizing collaborations. These partnerships enable SMEs to leverage the research capabilities of academic institutions to solve practical business challenges. For example, SMEs in the manufacturing and technology sectors have benefited from KTPs by adopting new technologies and improving their processes (Ternouth P. et al., 2012).

Regional Innovation Programs: Programs such as the "Need for Speed" (N4S) initiative have played a significant role. Launched to foster agile software development practices, N4S brought together multiple SMEs and

academic partners to work on cutting-edge projects. This collaboration enhanced the innovation capabilities of SMEs and also provided valuable real-world applications for academic research (Kettunen P. et a., 2022).

Those key milestones are benefit to SMEs in part of innovation and competitiveness, innovation and competitiveness, and resource efficiency. For innovation and competitiveness: collaborations with academia have allowed SMEs to stay at the forefront of technological advancements. By accessing cutting-edge research, SMEs can innovate more effectively and maintain a competitive edge in their respective markets. Access to talent: partnering with universities provides SMEs with a pipeline of skilled graduates who bring fresh perspectives and up-to-date knowledge. This is particularly beneficial for SMEs that may not have extensive resources for training new employees. And resource efficiency: SMEs benefit from the shared resources and expertise available through academic partnerships, which can lead to cost savings and more efficient R&D processes.

As the same time, those key milestones also benefic to academia part as real-world applications, enhanced curriculum, and research funding and opportunities. Academic researchers gain opportunities to apply their theoretical knowledge to practical problems, enhancing the relevance and impact of their work. For feedback from industry collaborations helps shape academic programs to better meet the needs of the job market, improving the employability of graduates. In addition, the collaborations often attract funding from both private and public sectors, supporting further research initiatives and enhancing the research capabilities of academic institutions.

From report of 2022 medium-size enterprise monitor represented that the SMEs in the Satakunta region of Finland face a dynamic environment with both opportunities and challenges. The region is characterized by a diverse mix of industries, including manufacturing, technology, and services, which provide a solid foundation for economic activities. However, like many other regions, Satakunta's SMEs are navigating several common issues such as access to financing, internationalization, and technological adoption. The key challenge of the current situation is 1) access to financing: one of the primary challenges for SMEs in Satakunta, as in many other regions, is securing adequate financing. SMEs often struggle with cash flow issues and obtaining credit, which can limit their ability to invest in growth and innovation, 2) technological adoption: there is a need for increased adoption of digital tools and advanced manufacturing technologies to remain competitive. The integration of new technologies requires significant investment and skilled personnel, which can be a hurdle for smaller enterprises, and 3) internationalization: expanding into international markets presents both opportunities and challenges. SMEs in the Satakunta region need to navigate different regulatory environments, cultural differences, and logistical complexities to succeed abroa.

The SMEs in the Satakunta region are pivotal to the local economy, contributing significantly to employment and economic activity. While they face challenges such as access to finance and the need for technological advancement, there are substantial opportunities through collaboration with academic institutions and support from government programs. By leveraging these resources, SMEs in Satakunta can enhance their competitiveness and drive regional economic growth. According to Statistics Finland, SMEs are defined as enterprises with fewer than 250 employees and either an annual turnover not exceeding EUR 50 million or a balance sheet total not exceeding EUR 43 million. Total Number of Enterprises: As of 2022, Finland had approximately 443,731 enterprises, excluding those in agriculture, forestry, and fishing. Micro-Enterprises: Enterprises with fewer than 10 employees constitute about 95% of all Finnish businesses. Small Enterprises: Those with 10 to 49 employees represent around 4% of the total. Medium-Sized Enterprises: Companies with 50 to 249 employees account for approximately 1% of businesses. Large Enterprises: Firms with 250 or more employees make up less than 0.2% of the total (Yrittäjät, 2022).

3. Key technology of the industry-academic collaboration-based SE for SMEs in Satakunta region

3.1 The technology and tools of the industry-academic collaboration-based SE for SMEs

Industry-Academic Collaboration: These collaborations aim to bridge the gap between theoretical research and practical applications, often resulting in innovative solutions and advancements in technology. One of the most powerful technology and tools is Generative AI and Large Language Models (LLMs). By leveraging generative AI, SMEs can enhance productivity, reduce costs, and maintain a competitive edge in the market. This allows them to operate more efficiently and effectively in various business aspects. And, the capabilities of LLMs, SMEs can significantly enhance their operations, improve customer engagement, and maintain a competitive edge in the market.

3.2 Generative AI

Generative AI refers to artificial intelligence systems capable of creating new content, such as text, images, music, or code, by learning patterns and structures from existing data. Unlike traditional AI, which performs tasks

based on predefined rules, generative AI can produce original, human-like outputs. Examples include GPT-3 for text generation, DALL-E for image creation, and OpenAI's Codex for generating programming code. These technologies are widely used for applications like chatbots, content creation, and design, offering powerful tools for innovation and efficiency in various industries.

Generative AI can play a significant role in Small and Medium-sized Enterprises (SMEs) by enhancing various aspects of their operations and strategies. Here are some key areas where generative AI can be particularly impactful:

3.2.1 Content Creation and Marketing

1) Automated Content Generation: Generative AI can create high-quality content for blogs, social media, and marketing campaigns, saving time and resources for SMEs.
2) Personalized Marketing: AI can generate personalized marketing messages and advertisements tailored to individual customer preferences, increasing engagement and conversion rates.

3.2.2 Product Development and Design

1) Prototyping and Design: AI can assist in generating design prototypes and product variations quickly, allowing SMEs to experiment with different ideas without extensive manual effort.
2) Custom Product Suggestions: Generative AI can analyze customer data to suggest new product features or entirely new products that meet emerging market demands.

3.2.3 Customer Service

1) Chatbots and Virtual Assistants: AI-powered chatbots can handle customer inquiries 24/7, providing immediate responses and freeing up human staff for more complex issues.
2) Automated Customer Feedback Analysis: AI can analyze customer feedback and reviews to generate insights into customer satisfaction and areas for improvement.

3.2.4 Data Analysis and Insights

1) Predictive Analytics: Generative AI can analyze historical data to forecast trends, helping SMEs make data-driven decisions in areas like inventory management, sales strategies, and financial planning.
2) Automated Reports: AI can generate detailed business reports and analytics, providing SMEs with actionable insights without needing a dedicated data team.

3.2.5 Human Resources and Recruitment

1) Resume Screening and Matching: AI can streamline the hiring process by generating shortlists of qualified candidates based on job requirements and applicant data.
2) Employee Training: AI can create personalized training programs and materials, ensuring employees receive relevant and effective training.

3.2.6 Supply Chain and Operations

1) Demand Forecasting: AI can generate accurate demand forecasts, helping SMEs optimize their supply chain and reduce inventory costs.
2) Process Automation: Generative AI can automate routine operational tasks, improving efficiency and reducing the likelihood of human error.

3.2.7 Creative Industries

1) Graphic Design and Media Production: AI can assist in generating graphics, videos, and other media content, providing SMEs with high-quality visual materials without needing extensive in-house expertise.
2) Music and Art Creation: For SMEs in the creative industries, AI can generate music, artwork, and other creative content, serving as a tool for inspiration and production.

3.2.8 Customer Experience and Personalization

1) Tailored Recommendations: AI can generate personalized product recommendations based on customer behavior and preferences, enhancing the shopping experience.
2) Customized Interactions: Generative AI can create personalized interactions and communications, improving customer satisfaction and loyalty.

3.2.9 Innovation and Competitive Advantage

1) New Business Models: AI can help SMEs innovate by generating ideas for new business models and strategies that leverage emerging technologies and market trends.
2) Competitor Analysis: AI can generate insights from competitor data, helping SMEs understand market positioning and identify opportunities for differentiation.

By leveraging generative AI, SMEs can enhance efficiency, creativity, and customer engagement, ultimately driving growth and competitiveness in their respective markets. There are some specific examples illustrating how generative AI can be leveraged in SMEs across different sectors:

3.2.10 E-commerce

1) Product Descriptions: An SME running an online store can use generative AI to automatically generate compelling and SEO-optimized product descriptions. For instance, instead of writing descriptions for each product manually, the AI can generate unique descriptions based on product features, saving time and ensuring consistency.
2) Customer Reviews Analysis: An AI system can analyze customer reviews and generate summaries or insights about common customer sentiments and feedback trends, helping the SME to understand customer preferences and improve products or services.

3.2.11 Marketing and Advertising

1) Content Creation: A small digital marketing agency can use generative AI tools to create social media posts, blog articles, and email newsletters. For example, an AI tool can generate a series of engaging posts for a month-long campaign, including text, hashtags, and even suggested images.
2) Ad Copy Generation: For SMEs focusing on advertising, generative AI can create multiple variations of ad copy for A/B testing, ensuring the most effective messages are used to attract customers.

3.2.12 Healthcare

1) Medical Report Generation: A small medical clinic can use AI to generate patient reports from raw data. For example, after a patient visit, the AI can compile the doctor's notes, lab results, and diagnosis into a comprehensive report for the patient.
2) Appointment Scheduling: AI can generate personalized reminders and follow-up messages for patients, improving appointment adherence and patient engagement.

3.2.13 Real Estate

1) Property Listings: A real estate agency can use AI to generate detailed property listings, including descriptions, features, and market comparisons. For instance, AI can take basic information about a property and generate a comprehensive listing that highlights its best features and compares it to similar properties in the area.
2) Market Analysis Reports: AI can generate market analysis reports, providing insights into trends, pricing, and demographics, which can be shared with clients to help them make informed decisions.

3.2.14 Manufacturing

1) Design Prototyping: A small manufacturing firm can use AI to generate design prototypes for new products. For example, generative design tools can create multiple iterations of a product design based on specified parameters, helping the company to explore a wide range of design possibilities quickly.
2) Predictive Maintenance: AI can generate maintenance schedules and alerts based on equipment data, predicting when machinery is likely to need maintenance and reducing downtime.

3.2.15 Hospitality

1) Personalized Guest Experiences: A small hotel or bed-and-breakfast can use AI to generate personalized recommendations for guests, such as local attractions, dining options, and activities based on their preferences and past behavior.
2) Automated Guest Communication: AI can handle guest inquiries and bookings through chatbots, providing instant responses and generating personalized messages that enhance the guest experience.

3.2.16 Finance

1) Financial Reports: A small accounting firm can use AI to generate financial reports for clients. For example, AI can take raw financial data and produce comprehensive reports that include income statements, balance sheets, and cash flow statements.
2) Expense Analysis: AI can analyze company expenses and generate insights on where costs can be reduced, helping SMEs manage their finances more efficiently.

3.2.17 Education and Training

1) Course Content Creation: An SME offering online courses can use AI to generate educational content, quizzes, and assignments. For instance, AI can create diverse sets of questions and interactive materials based on the course syllabus.
2) Personalized Learning Paths: AI can analyze student performance and generate personalized learning paths and recommendations, helping each student to progress at their own pace.

3.2.18 Customer Service

1) Automated Support Responses: An SME can deploy AI chatbots to handle common customer service queries, generate appropriate responses, and escalate more complex issues to human agents. This can significantly reduce response times and improve customer satisfaction.
2) Feedback Analysis: AI can analyze customer feedback from multiple channels and generate reports on customer sentiment, identifying key areas for improvement.

3.2.19 Creative Industries

1) Graphic Design: A small graphic design studio can use AI to generate logo concepts or design templates, speeding up the initial design phase and providing a broader range of options to clients.

2) Music and Art Generation: For a small business in the creative sector, AI can generate music tracks or artwork based on specific themes or styles, providing unique content that can be used in various projects or sold to clients.

These examples illustrate the versatility of generative AI in enhancing efficiency, creativity, and customer engagement across various industries within the SME sector.

3.3 Large Language Models (LLMs),

Large Language Models (LLMs) are a type of artificial intelligence designed to understand and generate human-like text based on vast amounts of data. They use deep learning techniques, particularly neural networks, to process and predict language patterns. LLMs are trained on diverse datasets, enabling them to perform various language-related tasks such as translation, summarization, question answering, and content generation.

Large Language Models (LLMs) like GPT-4 play a significant role in Small and Medium-sized Enterprises (SMEs) by enabling a variety of applications that enhance productivity, streamline operations, and provide competitive advantages. Here are some specific roles LLMs can play in SMEs:

3.3.1 Customer Support and Interaction

1) Automated Customer Service: LLMs can power chatbots and virtual assistants to handle customer queries, provide product information, and resolve issues efficiently. This ensures 24/7 customer support without the need for constant human intervention.
2) Personalized Responses: These models can generate personalized and context-aware responses to customer emails, improving customer satisfaction and engagement.

3.3.2 Content Creation and Marketing

1) Content Generation: LLMs can produce high-quality content for blogs, social media posts, newsletters, and marketing campaigns, saving time and resources for content teams.
2) SEO Optimization: They can assist in generating SEO-optimized content by suggesting keywords, meta descriptions, and improving readability, helping SMEs rank higher in search engines.
3) Ad Copywriting: LLMs can create compelling ad copy for various advertising platforms, enabling SMEs to run effective marketing campaigns.

3.3.3 Internal Communication and Documentation

1) Report Generation: LLMs can automate the creation of business reports, summaries, and analytics, providing insights and saving time for employees.
2) Meeting Summaries: They can transcribe and summarize meetings, ensuring that important points and action items are captured accurately.

3.3.4 Human Resources and Recruitment

1) Resume Screening: LLMs can analyze resumes and cover letters to identify the most suitable candidates based on job descriptions and requirements, streamlining the hiring process.
2) Employee Training Materials: They can generate training materials, FAQs, and onboarding documents tailored to specific roles within the company.

3.3.5 Sales and Customer Relationship Management (CRM)

1) Lead Generation: LLMs can help identify potential leads by analyzing customer data and generating targeted outreach messages.

2) Customer Insights: They can analyze customer interactions and feedback to provide insights into customer needs and preferences, helping SMEs tailor their sales strategies.

3.3.6 Product Development and Innovation

1) Idea Generation: LLMs can assist in brainstorming sessions by generating new ideas for products, features, or improvements based on current market trends and customer feedback.
2) Technical Documentation: They can create technical documents, user manuals, and product descriptions, ensuring clear and consistent communication about product functionalities.

3.3.7 Financial Management

1) Expense Reporting: LLMs can automate the creation of expense reports and financial summaries, providing SMEs with accurate financial insights.
2) Forecasting and Analysis: They can generate financial forecasts and perform trend analysis, helping SMEs make informed financial decisions.

3.3.8 Legal and Compliance

1) Contract Drafting: LLMs can assist in drafting and reviewing contracts, ensuring they meet legal requirements and reduce the risk of errors.
2) Regulatory Compliance: They can help SMEs stay updated with industry regulations by generating summaries of relevant legal updates and compliance requirements.

3.3.9 Customer Feedback and Sentiment Analysis

1) Feedback Analysis: LLMs can analyze customer feedback from various channels, such as surveys and social media, to gauge customer sentiment and identify areas for improvement.
2) Survey Creation: They can generate well-structured and relevant survey questions to gather valuable customer insights.

3.3.10 Knowledge Management

1) Document Retrieval: LLMs can help employees quickly find relevant documents and information within the company's knowledge base.
2) Knowledge Base Creation: They can assist in creating and maintaining an up-to-date knowledge base, ensuring that employees have access to the information they need.

3.3.11 Language Translation and Localization

1) Multilingual Support: LLMs can provide translation services, enabling SMEs to interact with customers and partners in multiple languages.
2) Content Localization: They can adapt marketing content and product information to different cultural contexts, improving global reach and customer relevance.

3.3.12 Creative Industries

1) Script Writing: For SMEs in media and entertainment, LLMs can assist in writing scripts for videos, podcasts, and other media content.
2) Creative Writing: They can generate story ideas, character descriptions, and plot outlines for authors and content creators.

By leveraging LLMs, SMEs can improve operational efficiency, enhance customer experiences, and drive innovation, ultimately leading to growth and success in their respective markets. They are some specific examples illustrating how Large Language Models (LLMs) can be utilized in SMEs across various sectors:

3.3.13 Retail and E-commerce

1) Customer Support Automation:
    - Example: An online clothing store uses an LLM-powered chatbot on their website to handle customer inquiries about order status, return policies, and product availability. This chatbot can provide instant responses, freeing up human agents to handle more complex queries.
2) Product Descriptions:
    - Example: An SME selling handmade crafts uses LLMs to generate detailed and appealing product descriptions for each item in their online store, ensuring consistency and improving SEO.

3.3.14 Marketing and Advertising

1) Content Creation:
    - Example: A small digital marketing agency leverages LLMs to create blog posts, social media updates, and email newsletters for their clients. The AI generates content ideas and drafts, which the human team then fine-tunes, significantly speeding up the content creation process.
2) Ad Copywriting:
    - Example: An SME specializing in eco-friendly products uses LLMs to generate variations of ad copy for their Google and Facebook ads, enabling them to perform A/B testing and identify the most effective messages.

3.3.14 Healthcare

1) Patient Communication:
    - Example: A small medical clinic employs an LLM to automate appointment reminders and follow-up messages for patients. The AI generates personalized messages based on patient data, improving appointment adherence and patient engagement.
2) Medical Documentation:
    - Example: Doctors at a clinic use LLMs to assist in writing detailed medical reports and patient notes after consultations, ensuring thorough and accurate documentation.

3.3.15 Real Estate

1) Property Listings:
    - Example: A small real estate agency uses LLMs to automatically generate engaging property descriptions for listings on their website, highlighting key features and amenities, and optimizing for search engines.
2) Client Communication:
    - Example: The agency also uses LLMs to draft personalized follow-up emails to clients after property viewings, summarizing the visit and suggesting similar properties.

3.3.16 Manufacturing

1) Technical Documentation:
    - Example: An SME manufacturing industrial equipment uses LLMs to create user manuals and maintenance guides. The AI ensures the documents are clear, comprehensive, and consistent, reducing the burden on technical writers.
2) Customer Support:

- Example: The company also employs an LLM-powered chatbot to assist customers with troubleshooting common issues and providing maintenance tips.

3.3.17 Education and Training

1) Course Content Development:
   - Example: A small online education platform uses LLMs to generate course materials, including lecture notes, quizzes, and assignments, for various subjects. This helps educators save time and focus on interactive teaching.
2) Student Support:
   - Example: The platform also offers an AI-driven virtual tutor that helps students with homework questions and provides explanations for difficult concepts.

3.3.18 Financial Services

1) Financial Reports:
   - Example: A small accounting firm uses LLMs to automate the creation of financial reports for their clients. The AI processes raw financial data and generates detailed reports, including insights and trend analysis.
2) Expense Analysis:
   - Example: The firm also uses LLMs to analyze clients' expense data and generate recommendations for cost savings and budget optimization.

3.3.19 Legal Services

1) Contract Drafting:
   - Example: A small legal practice uses LLMs to draft standard contracts and legal documents. The AI ensures that documents are correctly formatted and include all necessary clauses, reducing the time spent on routine paperwork.
2) Legal Research:
   - Example: The practice also uses LLMs to conduct legal research, generating summaries of relevant case law and statutes to support their legal arguments.

3.3.20 Hospitality

1) Guest Communication:
   - Example: A boutique hotel uses LLMs to manage guest communications, from booking confirmations to personalized recommendations for local attractions and dining options.
2) Review Analysis:
   - Example: The hotel also employs LLMs to analyze online reviews, extracting key themes and sentiments to improve guest experiences and address any recurring issues.

3.3.21 Consulting

1) Proposal Writing:
   - Example: A small consulting firm uses LLMs to draft detailed project proposals and reports for their clients, ensuring that each document is tailored to the client's specific needs and challenges.
2) Market Research:
   - Example: The firm also uses LLMs to analyze industry reports and generate market insights, helping them provide well-informed advice to their clients.

These examples demonstrate how LLMs can be applied across various functions in SMEs, enhancing efficiency, improving customer experiences, and driving innovation.

3.4 The integration of regulatory Artificial Intelligent (AI) based SE for SMEs in Satakunta region

The AI Act refers to the proposed regulatory framework by the European Union to ensure the safe and trustworthy development, deployment, and use of Artificial Intelligence (AI) across the EU. AI Act-based Software Engineering involves designing, developing, and maintaining software systems that comply with the requirements outlined in the AI Act. Here's an overview of what AI Act-based Software Engineering entails:

3.4.1 Key Components of the AI Act as Risk-based Classification.

1) Unacceptable Risk: AI systems that pose a threat to safety, livelihoods, or rights are banned.
2) High Risk: AI systems used in critical areas such as healthcare, transport, law enforcement, and employment are subject to strict obligations.
3) Limited Risk: AI systems with specific transparency obligations, such as chatbots, need to inform users they are interacting with an AI system.
4) Minimal Risk: AI systems with minimal or no risk, such as AI-enabled video games or spam filters, have minimal regulatory requirements.

3.4.2 AI Act-Based Software Engineering Practices

1) Risk Assessment and Management:
    - Risk Identification: Identifying potential risks associated with the AI system based on the AI Act's classification.
    - Risk Mitigation: Implementing measures to mitigate identified risks, especially for high-risk AI systems.
2) Compliance by Design:
    - Requirement Analysis: Integrating compliance requirements from the AI Act into the software development lifecycle from the outset.
    - Documentation: Maintaining detailed documentation to demonstrate compliance with the AI Act, including design choices, data sources, risk management processes, and testing protocols.
3) Data Governance:
    - Data Quality: Ensuring that data used for training AI systems is of high quality, accurate, and representative.
    - Data Privacy: Complying with GDPR and other relevant data protection laws to ensure the privacy and security of personal data used by AI systems.
4) Transparency and Accountability:
    - User Information: Providing users with clear information about the AI system's capabilities and limitations.
    - Auditability: Implementing mechanisms to allow for the auditing of AI systems to verify compliance with regulatory requirements.
5) Human Oversight:
    - Human-in-the-loop (HITL): Ensuring that high-risk AI systems include mechanisms for human oversight to intervene and override decisions made by the AI.
    - User Training: Providing adequate training to users and operators of AI systems to understand and manage the AI's outputs effectively.
6) Robustness and Safety:
    - Testing and Validation: Conducting rigorous testing and validation to ensure the AI system operates reliably and safely under expected conditions.
    - Monitoring: Implementing continuous monitoring to detect and address any deviations or failures in the AI system's performance.

3.4.3 Example Applications

1) Healthcare:
    - Diagnostic Tools: Ensuring AI-based diagnostic tools comply with high-risk requirements, including data quality, transparency, and human oversight to make safe and accurate medical diagnoses.
    - Medical Devices: Developing AI-powered medical devices that meet strict safety and performance standards mandated by the AI Act.
2) Transportation:
    - Autonomous Vehicles: Implementing robust safety measures and real-time monitoring systems to ensure autonomous vehicles comply with high-risk regulations.
    - Traffic Management: Designing AI systems for traffic management that incorporate transparency and human oversight to manage urban traffic flows safely and efficiently.
3) Employment:
    - Recruitment Systems: Ensuring AI-based recruitment systems are fair, transparent, and do not discriminate, complying with high-risk requirements.
    - Performance Monitoring: Developing AI tools for employee performance monitoring that respect privacy and transparency obligations.
4) Law Enforcement:
    - Facial Recognition: Implementing strict safeguards and accountability measures for AI-based facial recognition systems used by law enforcement agencies.
    - Predictive Policing: Ensuring that AI systems used for predictive policing are transparent, unbiased, and subject to human oversight.

3.4.4 Benefits of AI Act-Based Software Engineering

1) Legal Compliance: Ensures that AI systems comply with European regulatory standards, reducing the risk of legal penalties and reputational damage.
2) User Trust: Enhances user trust by ensuring transparency, fairness, and accountability in AI systems.
3) Safety and Reliability: Promotes the development of safe and reliable AI systems that can be effectively monitored and managed.
4) Market Access: Facilitates access to the European market by ensuring that AI products and services meet regulatory requirements.

In summary, AI Act-based Software Engineering involves integrating the regulatory requirements of the EU AI Act into the software development process, ensuring that AI systems are safe, transparent, accountable, and compliant with legal standards. This approach not only helps in mitigating risks but also builds trust and fosters innovation in the AI landscape.

3.5 The initial situation of AI and Generative AI of SMEs in Satakunta region

3.5.1 Elinar Oy Ltd
- Location: Pori, Finland
- Application: Specializes in AI-assisted content and information management, leveraging generative AI to automate document processing and enhance data management solutions.

3.5.2 HeadAI
- Location: Pori and Espoo, Finland
- Application: Develops General Semantic AI to enable explainable and transparent decision-making, utilizing generative AI to process and generate insights from complex data sets.

3.5.3 Bluugo
- Location: Pori & Vantaa, Finland
- Application: Develops award-winning machine learning and IoT solutions with their Tracking Cloud platform, utilizing AI to enhance tracking and data analytics capabilities.

3.5.4 CI Computational Intelligence
- Location: Pori, Finland

- Application: Specializes in computational intelligence to optimize staff rostering, shift generation, and other scheduling tasks, employing AI to improve operational efficiency.

3.5.5 Hubble

- Location: Pori, Finland
- Application: An agile software developer with a mission to humanize artificial intelligence and technology, focusing on creating user-friendly AI applications.

3.5.6 Koivu Solutions

- Location: Ulvila, Finland; Nashville, TN, USA
- Application: Assists businesses in digitalization initiatives, leveraging AI to enhance business processes and drive digital transformation.

3.5.7 Satakunta University of Applied Sciences (SAMK)

- Location: Pori, Finland
- Application: Engages in research projects employing generative AI in medical research, focusing on data analysis and predictive modeling to advance healthcare solutions

3.5.8 Caverion Suomi Oy (Pori Aittaluoto)

- Location: Pori, Finland
- Application: its partnership with Telia by implementing artificial intelligence (AI) solutions to enhance the maintenance of Telia's data centers. These AI-driven systems improve environmental monitoring and operational efficiency.

3.5.9 Fonecta Media Oy

- Location: Pori, Finland
- Application: Fonecta has further embraced artificial intelligence (AI) across its operations. Fonecta initiated internal pilot projects, such as developing an AI-powered chatbot for employee inquiries and implementing AI-driven analysis of customer call recordings to extract valuable insights. These initiatives demonstrate Fonecta's commitment to integrating AI into its processes to improve efficiency and service quality.

3.5.10 Nakkila Works Oy,

- Location: Nakkila, Finland
- Application: Company works in the ReBoot Satakunta project, focusing on advancing digitalization through robotics.

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