TEST AUTOMATION AND AI

Lappeenranta–Lahti University of Technology LUT

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ABSTRACT

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63 pages, 4 figures, 3 tables and 1 appendices

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Keywords: Software Testing, Test Automation, Artificial Intelligence, Quality Assurance.

Over the past years artificial intelligence has been in the growing hype, and the expectations towards it are high. There is a desire to use AI in all areas, including testing and test automation. The results of this study can be used to get a general overview of how AI is currently being used in test automation.

This paper examines both the status of AI in test automation as well as the test automation activities in which AI is currently being utilized. It also investigates how AI is implemented into software testing projects including the potential, benefits, and limitations of implementing AI. Additionally, the required skills and tools are discussed, and the future of AI is evaluated.

The theoretical part of the thesis is mainly based on topical articles about test automation, artificial intelligence, and quality assurance. In this thesis, a wide variety of materials has been used as references and the aim has been to rely on the most up-to-date theories. The research was done as a qualitative case study for a Finnish company that focuses on the design and development of digital services with around 200 experts in testing. For the research, 5 interviews were conducted remotely via Microsoft Teams and face-to-face meetings using a predetermined set of questions. Interviews were held in March 2024, which is why the results reflect the situation in spring 2024 within the case company.

The most important research results reveal that regardless of the high expectations of AI in test automation, it is not completely utilized yet. There are still ethical considerations, regulations, and security aspects, that must be clarified before companies are willing to give their critical data to AI. According to the results, AI is currently mainly used in test scripting and test planning tasks only. Potential for AI is seen as high, and that AI can be used in all test automation activities in the future.

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Viime vuosina tekoäly on ollut kasvavan kiinnostuksen kohteena, ja siihen kohdistuvat odotukset ovat korkealla. Tekoälyä halutaan käyttää kaikilla aloilla, myös testauksessa ja testiautomaatiossa. Tämän tutkimuksen tulosten avulla saadaan yleiskuva siitä, miten tekoälyä käytetään tällä hetkellä testiautomaatiossa.

Tässä tutkielmassa tarkastellaan tekoälyn asemaa testiautomaatiossa ja sitä, missä testiautomaatiotoiminnoissa tekoälyä hyödynnetään tällä hetkellä. Tutkielmassa tutkitaan myös, miten tekoäly jalkautetaan ohjelmistotestausprojekteihin, sekä tekoälyn käytön mahdollisuuksia, hyötyjä ja rajoituksia. Lisäksi käsitellään tarvittavia taitoja ja työkaluja sekä arvioidaan tekoälyn tulevaisuutta.

Tutkielman teoriaosuus perustuu pääasiassa ajankohtaisiin artikkeleihin, jotka käsittelevät testausautomaatiota, tekoälyä ja laadunvarmistusta. Tutkielmassa on käytetty monipuolisesti erilaisia aineistoja lähteinä, ja tavoitteena on ollut tukeutua mahdollisimman ajankohtaisiin teorioihin. Tutkimus on tehty kvalitatiivisena tapaustutkimuksena suomalaiselle digitaalisten palveluiden suunnitteluun ja kehittämiseen keskittyvälle yritykselle, jossa on noin 200 testauksen asiantuntijaa. Tutkimusta varten tehtiin 5 haastattelua etänä Teamsin kautta ja kasvokkain käyttäen ennalta määriteltyä kysymyssarjaa. Haastattelut pidettiin maaliskuussa 2024, minkä vuoksi tulokset kuvastavat kevään 2024 tilannetta case-yrityksessä.

Tärkeimmät tutkimustulokset paljastavat, että vaikka tekoälyyn kohdistuu suuria odotuksia, sitä ei vielä hyödynnetä täysin testiautomaatiossa. Vielä on eettisiä pohdintoja, säännöksiä ja turvallisuuskysymyksiä, jotka on selvitettävä ennen kuin yritykset ovat valmiita antamaan kriittistä dataansa tekoälyn käyttöön. Tulosten mukaan tekoälyä käytetään tällä hetkellä pääasiassa vain testiskriptaus- ja testaussuunnittelutehtävissä. Tekoälyn potentiaalia pidetään korkeana, ja nähdään, että tekoälyä voidaan käyttää tulevaisuudessa kaikissa testiautomaatioaktiviteeteissa.

ABBREVIATIONS

AI	Artificial Intelligence
CI/CD	Continuous Integration/Continuous Delivery
DL	Deep Learning
NLP	Natural Language Processing
ML	Machine Learning
TA	Test Automation
UX	User Experience
UI	User Interface
QA	Quality Assurance

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1 Introduction

In recent years, artificial intelligence (AI) has revolutionized software engineering and other processes related to it, including testing and quality assurance. AI can be used to automate manual tasks and to solve more complex problems as AI advances rapidly. AI's influence has extended to enhancing testing procedures, ensuring code quality, and expediting development timelines. (Gartner 2023.) This master's thesis investigates the significant impact AI has had on test automation, examining its advantages, limitations, and how it is implemented into software testing projects.

In the rapidly evolving landscape of software development, the demand for efficiency, reliability, and speed has never been greater. Test automation stands as a cornerstone in meeting these demands, offering a transformative approach to software testing that enhances productivity, mitigates risks, and accelerates time-to-market. By leveraging automation tools and frameworks, organizations can enhance their testing processes, reduce manual effort, and ensure robustness across their software products. Test automation is automating manual testing by using other software, test automation tools.

Dustin, Rashka & Paul (1999) have defined test automation as:

> "Management and performance of test activities, to include the development and execution of test scripts so as to verify test requirements, using an automated test tool." (Dustin et al. 1999)

Because of the competition, testing should be high-quality and efficient at the same time, and artificial intelligence offers a solution to this, and makes testing smarter. It is important to explore the fundamental concepts of AI, its applications in test automation, and the impact of AI-powered tools on the software testing industry. By integrating scholarly articles and research papers that discuss the role of AI in test automation, this master's thesis can provide a comprehensive understanding of how AI is transforming the field of software testing.

The aim of this thesis is to compare the theory collected from the resources with the data collected from interviews in the case company and give an actual review of how AI is currently used. The use of AI in test automation is still limited, and this study aims to find out how AI is currently utilized in test automation in reality, as the literature focuses mostly on the opportunities of AI. The research questions were described to help at answering to

the questions of the current status of AI in test automation. The research questions are presented below.

RQ1: What is the current status of AI in test automation?

RQ2: How is AI implemented into software testing projects?

RQ3: What skills and tools are required?

RQ4: What are the limitations of implementing AI?

RQ5: How is the future of AI and test automation seen?

The theoretical part of the thesis was mainly based on topical articles about test automation, artificial intelligence, quality assurance, software development and AI. The thesis aimed at using a wide variety of materials as references and the aim was to rely on the most up-to-date theories. The empirical part was done as a qualitative case study for a Finnish company that focuses on the design and development of digital services that has around 200 experts in testing. 5 interviews were conducted for the research via Microsoft Teams and face-to-face meetings using a predetermined set of questions. As this research and interviews were done for a specific case company, the results cannot be interpreted to be universal. Also, interviews were held in March 2024, which must be considered when viewing the results. The results may be out of date in a year or two, if AI continues to develop at this pace.

The thesis is structured as follows: Sections 2 and 3 provide a review of the literature that serves as the foundation for the research. Section 2 reviews the literature on testing and test automation, and section 3 on artificial intelligence and test automation. Section 4 explains goal of the research, research method and presents the interviewees and case company. Section 5 presents the results and answers to research questions. Section 6 discusses the results of the research, followed by section 7, which summarizes the whole process from the topic to the findings and conclusions.

2 Software testing and test automation

Software testing is a critical part of software development. This section provides an academic overview of software testing and why testing is crucial part of software development. It also explains what is test automation, that is used to perform software testing activities more effective than manual testing and describes the test automation activities.

2.1 Software testing

According to Jose (2021) software testing process is part of software development, and it aims at validating that the software meets its requirements and fits for its purpose. According to Anand and Uddin (2019), software testing plays a pivotal role in the development lifecycle of software systems, serving as a critical mechanism for validating functionality, assessing quality, and mitigating risks. Testing is a crucial part of software development, and it decreases the number of defects, and financial and reputational damage when software is in production. Selecting of suitable testing methodology, type, and technique for validating requirements depends on the software to be tested. Through systematic examination and evaluation of software, testing endeavors aim to identify defects, anomalies, and deviations from specified requirements, thereby ensuring the reliability, robustness, and performance of software applications. (Jose, 2021.)

According to the IEEE standard glossary of software engineering terminology, testing can be determined as:

> "Testing is the process of operating a system or component (or unit) under specified conditions, observing, or recording the results, and making an evaluation of some aspect of the system or component." (IEEE, 1990)

Software testing encompasses a diverse array of techniques, ranging from manual inspection and walkthroughs to automated test execution and analysis. The selection and application of appropriate testing methods depend on various factors, including project constraints, development methodologies, and application domains. Moreover, the emergence of agile and DevOps practices has led to a paradigm shift in testing approaches, emphasizing

continuous integration, continuous testing, and test automation to enable rapid and iterative delivery of high-quality software products. (Al-Saqqa, Sawalha & Abdel-Nabi, 2020.)

In the software quality assurance (QA), significant time and effort are allocated to the validation of new code for compatibility with existing systems. The integration of new code necessitates the creation of corresponding test suites, a process that is conventionally performed manually. This manual regression testing process, characterized by iterative cycles, poses notable challenges for QA personnel, consuming substantial time, and exerting pressure on their resources. (Lawanna, 2012)

According to Arumugam (2020), traditional QA methodologies typically involve the systematic verification of predetermined tasks to ensure the functionality of software in accordance with its intended design. While such an approach suffices for assessing a limited set of features, its efficiency diminishes when confronted with the testing requirements of more extensive software functionalities. As QA professionals' endeavor to encompass a broader spectrum of features within their testing activities, they encounter difficulties in adhering to project deadlines due to the inherently time-consuming nature of manual testing procedures. (Arumugam, 2020.)

Furthermore, the testing of complex software applications introduces additional layers of complexity, highlighting the challenges faced by QA teams. In such scenarios, the manual execution of testing protocols becomes particularly exhausting, necessitating the exploration of alternative methodologies to enhance efficiency and effectiveness. (Lawanna, 2012)

2.2 Test automation

In manual testing, the tester assumes the role of the end user and performs tests on the software according to the test cases. Test automation (TA) is automating manual testing by using other software, test automation tools and test scripting. (Garousi & Elberzhager, 2017.) It includes automating functions and parts of testing processes, and it uses a special software to control and execute tests. Test automation is usually used when testing is time-consuming, or if manual testing is not possible. It is used to reduce testing effort, but all manual testing cannot always be automated. Test automation is commonly used in various industries

resulting to cost reduction, and more efficient and accurate testing if it is used correctly. (Jose, 2021.)

With the help of test automation, software testing is significantly accelerated. Software are more extensive and complex, and software producers are willing to release new features as quickly as possible without the time required for manual testing. Thereby, using test automation speeds up the release of versions and the competitiveness of the software in the market. Implementation of test automation is a strategic decision that should be made carefully. Also, it is crucial to carefully select the test cases that will be automated and the ones that will be still tested manually. (Khankhoje, 2023)

According to Graham & Fewster (2012), it is vital to distinguish between the elements involved in the automation process and the actual test parameters. Automation serves as a mechanism for executing tests but remains neutral regarding the quality of the tests themselves. It is important to emphasize that the implementation, maintenance, and analysis of failed automated tests can consume more time when compared to manual testing. An illustrative example is regression testing, which benefits from automation due to its repetitive nature. It is essential to recognize that manual testing and test automation complement each other, operating in tandem rather than being mutually exclusive. (Graham et al. 2012).

Test automation is a software development project that must be continuously maintained. It can be compared to any software project as it applies same software engineering practices, skills, and expertise. (Goericke, 2020; Jose, 2021.) The Table 1 below summarizes the advantages and disadvantages of test automation according to Jose (2021).

Table 1. Advantages and disadvantages of test automation

Advantages	**Disadvantages**
Quick and reliable	Less coverage no negative and exploratory testing
Consistent and comprehensive	Static testing and reviews
Repeatable	Tools incur high costs
Programmable and reusable	Analysis of test result is time and cost intensive
Reduces time for testing	Requires sound coding skills
Improves the productivity of human testing	High maintenance cost
Provides a detailed test log	Not effective method for sort-term projects
Highly recommended for graphical user interface and performance testing	Application needs to be stable enough to execute automated scripts
Assured test coverage	Software testing tools often introduce their own defects
Support of all testing types and phases	

According to Jose (2021), test automation offers numerous advantages and disadvantages that impact software development projects. On the positive side, test automation can significantly improve testing efficiency, reduce testing time, and enhance test coverage. By automating repetitive and tedious testing tasks, teams can focus on more critical aspects of software development, leading to faster delivery times and improved overall quality. Additionally, automated tests provide consistent and reliable results, enabling early detection of defects and facilitating regression testing. However, test automation also presents challenges and limitations. One major disadvantage is the initial investment required in terms of time, resources, and expertise to set up and maintain automation frameworks and test scripts. Complex applications may pose difficulties in automating certain test scenarios, leading to gaps in test coverage and potential false positives or negatives. Moreover, automated tests may lack the human intuition and judgment needed to identify subtle defects or assess the user experience effectively. (Jose, 2021.)

Furthermore, test automation is not suitable for all types of testing, such as exploratory testing or usability testing (UX), where human intervention and creativity are essential. Additionally, poorly designed, or outdated automation scripts can become a maintenance burden, requiring frequent updates and refinements to keep pace with evolving software requirements. To maximize the advantages of test automation and mitigate its drawbacks, organizations must carefully evaluate their testing needs, invest in appropriate automation tools and training, and strike a balance between automated and manual testing approaches based on the specific requirements of each project. (Rafi, Moses, Petersen & Mäntylä, 2012).

Test automation relies on popular frameworks such as Selenium, Robot Framework, Cucumber, and PyTest, each offering distinct advantages for software testing. Selenium WebDriver stands out for its broad support for web application testing across multiple programming languages. Robot Framework's keyword-driven approach makes it ideal for acceptance testing, while Cucumber's human-readable format fosters collaboration through behavior-driven development. PyTest's simplicity and scalability make it a top choice for Python-based projects. The popularity of each framework varies based on project needs, programming language compatibility, and community support. (LambdaTest 2023.)

2.3 Test automation activities

According to Trudova, Dolezel & Buchalcevova (2020), test automation is much more than only automated test scripting and test execution. It also includes other activities of the software testing process as generating and selection test cases, generating test data, reporting test results, repairing tests, and selecting test cases. Test automation activities and their cycle are presented below in the Figure 1.

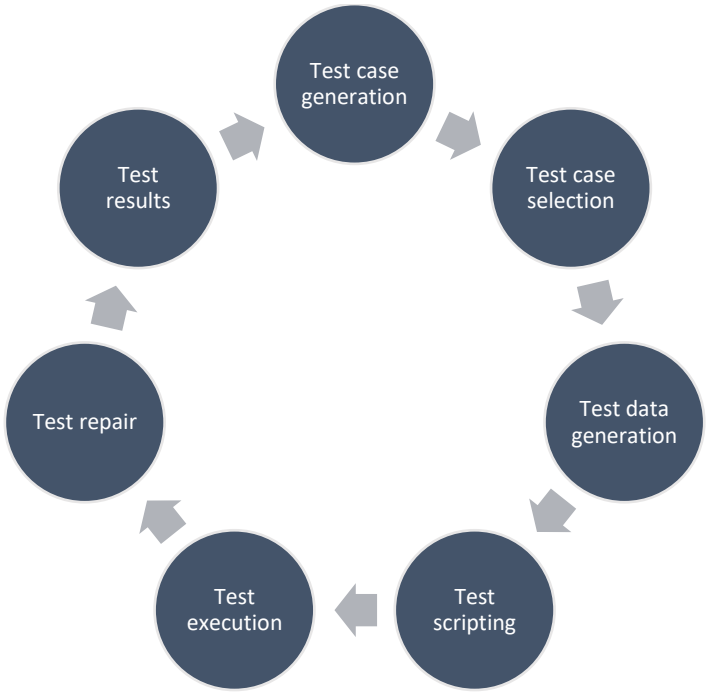

Figure 1. Test automation activities.

Test case generation is a process of creating a sequence of tests and their test steps for testing the software.

Test case selection is an activity for selecting suitable test cases from a test suite. It also includes removing outdated and duplicate test cases.

Test data generation is a process of creating the suitable data for test cases, that corresponds to the data used in production.

Test scripting is a process of scripting the automated tests.

Test execution is a process of executing the test cases and recording the results.

Test results reporting is a collection of test outputs that is generated after test execution.

Test repair is a process of maintaining and adjusting test scripts and fixing bugs.

All these TA activities are important part of the testing process, and they are interdependent. Overall, test automation activities aim to improve testing efficiency, increase test coverage, and accelerate the software delivery process by leveraging automation tools and techniques to execute repetitive and time-consuming testing tasks. (Trudova et al. 2020.)

Wang (2018) mentions in their study, that the process of implementing test automation also requires strategy work: defining the reasons and goals for test automation, analyzing risks and estimating of efforts needed for test automation. Also, resources are needed: skilled people, testing tools, test environments, hardware, test data and test environments. These can be also included into test automation activities as preliminary tasks, that are needed to be done before the actual test automation activities can be done. (Wang, 2018.)

3 Artificial intelligence and test automation

The utilization of artificial intelligence in software testing and quality assurance has evolved along the development of AI. This section describes how artificial intelligence can be utilized in test automation. It explains what AI is, in which test automation activities AI can be utilized, and what are the benefits and challenges of using it. It also introduces a few popular AI-based tools that are utilized in test automation.

3.1 Artificial intelligence

Over the past few decades, AI and Machine Learning (ML) have been increasingly utilized across various fields to harness the potential of data. ML techniques enable machines to efficiently process data by emulating the learning process observed in rational beings, employing AI algorithms that reflect different paradigms such as connectionist, genetic, statistical, probabilistic, and case-based approaches. Through the integration of AI algorithms with ML methodologies, it becomes feasible to explore and extract valuable insights from data, facilitating tasks such as classification, association, optimization, clustering, forecasting, and pattern recognition. (Lima, da Cruz & Ribeiro 2020.)

Artificial intelligence is a rapidly evolving field of computer science that focuses on creating systems capable of performing tasks that normally require human intelligence. According to Kayid (2020), AI aims at developing self-guiding machines and systems that interact with their environment, optimize their behavioral patterns, and learn from endeavors and mistakes like humans. It encompasses subfields such as machine learning, deep learning, natural language processing (NLP) and expert systems (Hourani, Hammad & Lafi, 2019). An expert system is a computer program, which is designed to imitate the decision-making abilities of a human expert in a specific field using AI techniques. Deep learning (DL) can automatically learn and train from large datasets to obtain excellent feature expression, which effectively improves the performance of various ML tasks and is widely used in computer vision, NLP, and other fields (Fang, Xue, Shen & Sheng, 2021). Figure 2 below describes the relationship of AI, ML and DL.

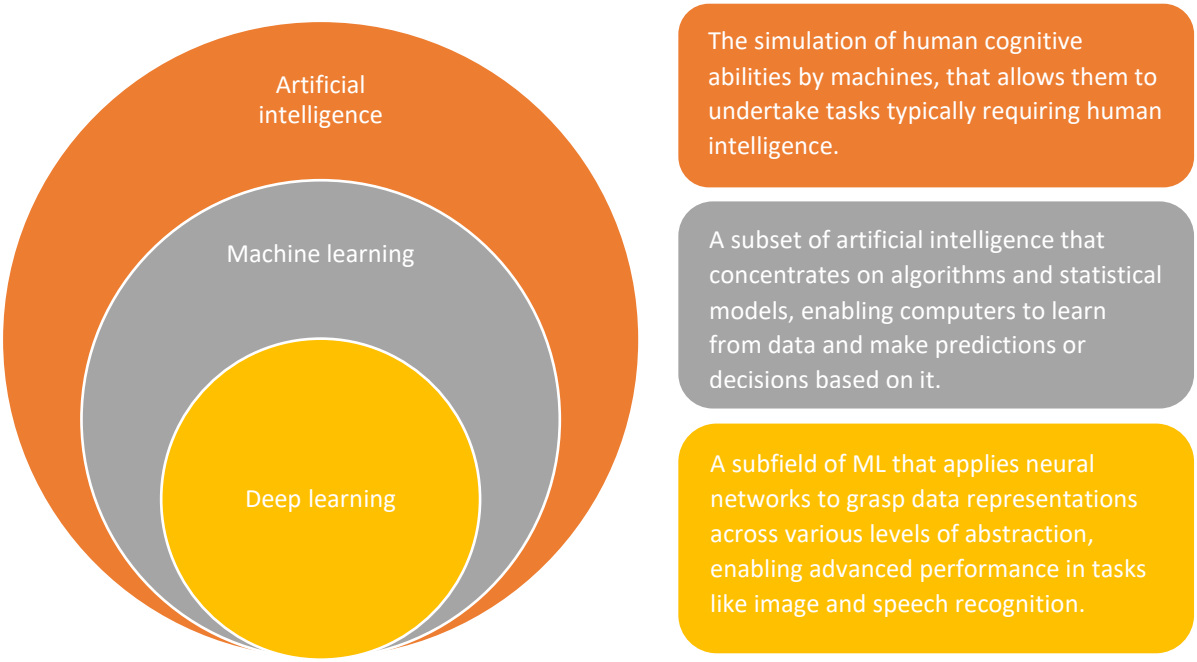

Figure 2. Relationship among Artificial Intelligence, Machine Learning and Deep Learning.

NLP refers to the capability of a machine or system to analyze and understand human-generated text. Its functions include generating text, responding to user queries, identifying context within text, and categorizing or translating it. The primary goal of NLP is to enable communication with humans and to learn from human language patterns. A significant portion of AI algorithms involves NLP, as AI systems are designed to perform tasks that humans can express in natural language. One example is ChatGPT that is a conversational AI model developed by OpenAI, which utilizes NLP. (Goar, Yadav & Yadav, 2023.)

According to Gupta and Mangla (2020) AI, as a form of technology, simulates human intelligence to execute tasks. It involves the use of AI-powered software and systems to generate written content, reduce the time needed for content creation, and provide more accurate writing. AI requires large amounts of data to train and can present both ethical and legal challenges, so it is important to consider these before utilizing AI. AI has various applications, including test automation, where AI-powered tools are used to enhance the efficiency and effectiveness of software testing processes. (Gupta et al. 2020.)

3.2 AI and test automation

Artificial intelligence in test automation represents a transformative frontier in computer science, creating systems that emulate human intelligence. In this rapidly evolving field, AI applications, as highlighted by Kayid (2020) and Gupta et al. (2020), extend to enhancing software testing processes. Trudova et al.'s (2020) literature study illustrates AI's pivotal role in test script generation and adaptive learning, leading to benefits such as reduced manual effort, improved code coverage, and increased reusability of test cases. One of the greatest strengths brought by artificial intelligence is the elimination of human-like errors and the increase in accuracy and precision. Decisions made by artificial intelligence based on accurate and timely information can practically eliminate errors.

AI has reshaped the landscape of the software testing industry, with the emergence of AI-powered tools for test automation changing the way QA teams approach their tasks. AI in test automation involves the simulation of human cognitive abilities to assist QA teams in more advanced tasks, such as test script generation and adaptive learning. According to Fontes, Gay, Neto & Feldt (2023) AI techniques include optimization, ML, NLP and other processes that enables learning of transferable testing skills. AI-augmented testing tools can improve all stages of the software testing, enhancing the efficiency and effectiveness of software testing processes. Software can be capable of autonomously conduct self-testing or enhancing its functionality. (Fontes et al. 2023.)

The literature study by Trudova et al. (2020) analyses usage of AI in several testing activities. According to their analysis, AI techniques are mostly beneficial in test case generation and test case oracle generation. AI is the next most beneficial in test execution and test data generation, followed by test results reporting. The most crucial benefits of using AI in test automation are manual effort reduction, improved code coverage, improved fault and vulnerability detection effectiveness, reusability of created test cases, test breakage repair, voidance of redundant actions during the test execution, improvement of existing solutions, and improved adequacy of the generated test cases. (Trudova et al. 2020.)

The most important benefit of manual effort reduction can be achieved by the reduction of time and costs of creation of tests, test execution and test maintenance. Implementing AI in test automation not only improves the speed and accuracy of testing but also enables QA teams to focus on more complex and critical aspects of software testing. By leveraging AI,

organizations can achieve higher test coverage, faster time-to-market, and improved software quality. (Khankhoje, 2024.) According to Hourani et al. (2019), using AI enhances competitiveness, and it can be used to shorten the software development life cycle and reduce time to market as seen in the Figure 3 below.

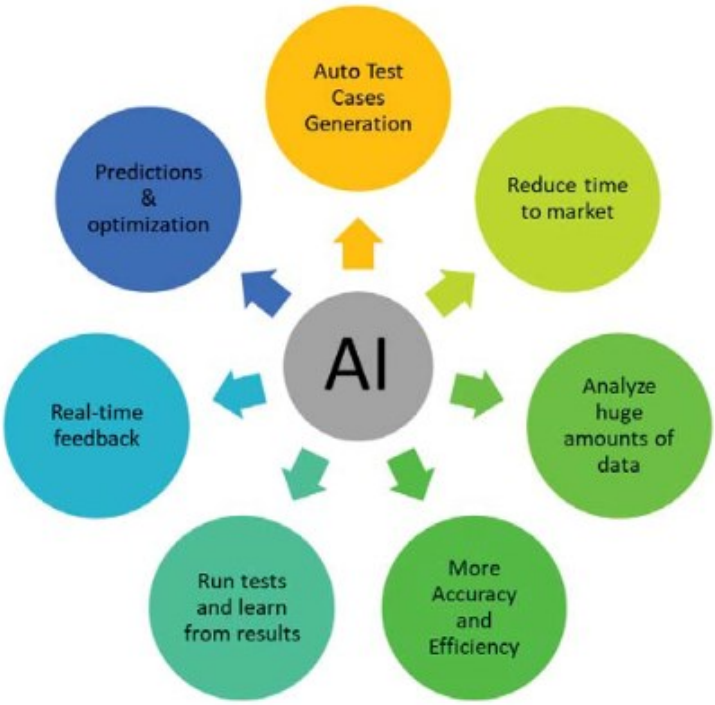

Figure 3. The key advantages of AI in software testing (Hourani et al. 2019).

Hourani et al. (2019) define that the key advantages of using AI in testing are automatic test case generation, reducing time-to-market, quick data analysis, more accuracy and efficiency testing. It also can be used to run test and learn from the results, and it provides real-time feedback, not to forget that it also gives predictions and enhances optimization.

3.3 AI and test automation processes

The integration of AI has demonstrably enhanced the speed, precision, and efficacy of software testing procedures. Through the utilization of AI algorithms, software testing processes benefit from advanced capabilities such as the analysis of enormous datasets and the automated generation of test cases, thereby facilitating considerable time savings for users. Moreover, AI technologies exhibit the capacity to anticipate potential issues pre-emptively, enabling development teams to proactively address emerging challenges.

Consequently, the incorporation of AI in software testing practices not only accelerates testing procedures but also elevates the accuracy and efficiency of the overall testing endeavour. (Khankhoje, 2024.)

Based on the literature of Felderer, Enoiu & Tahvili (2023) and Trudova et al. (2020), most of the test automation tasks exhibit repetitive characteristics. Within the realm of quality assurance, there exists a notable potential for automation to be leveraged effectively. Furthermore, AI can be used to speed up or even complete the test automation activities. The implementation of AI in software testing encompasses various critical tasks aimed at enhancing efficiency and accuracy. Firstly, AI can be used in generating test cases, which involves identifying and creating the requisite test cases through tasks such as code analysis. Additionally, AI assists in selecting test cases for automation and generating test data. AI is capable of test scripting by either scripting directly or supporting test automation developers in the process, and it can execute tests, automatically repair errors, or assist in debugging. Finally, AI generates and verifies test results. Moreover, AI-based software exhibits proficiency in generating comprehensive test cases for all user interface (UI) workflows, leveraging UI components as fundamental elements. Furthermore, AI technology plays a pivotal role in performance and load testing endeavors, ensuring system resilience under varying operational conditions. (Feldered et al. 2023; Hourani et al. 2019; Trudova et al. 2020) However, Ricca, Marchetto & Stocco (2021) present in their study, that AI is mainly applied in unit, regression, and functional end-to-end testing, and utilizing it in other testing levels is more challenging.

According to Felderer et al. (2023), there are four levels of autonomy of AI in testing. On level 0 AI is not applied, and testing is performed without AI. On level 1, AI algorithms are used to perform (semi-)automate testing tasks: AI is utilized to support in test design, analysis, execution, and evaluation activities. On level 2, AI is used to replace or mimic human behavior: AI is utilized to replace human behavior by intelligent agents. On level 3, AI agents are performing fully automated testing. The level 3 is seen as just a vision, and currently it is not clear if it will be possible or not. (Felderer et al. 2023)

3.4 Challenges of AI in software testing

AI has the potential to revolutionize the field of software testing by automating various test processes and improving efficiency. However, the implementation of AI in test automation is not without challenges. Ethical and legal considerations arise due to the substantial data required for AI model training. Test engineers face challenges in assessing AI system quality, managing associated risks, and ensuring trustworthiness in decision-making. Also, difficulty in reproducing and explaining results is seen as a challenge. (Smith, 2022.) Challenges include addressing the lack of domain-specific knowledge in AI models, the necessity for diverse datasets, and complexities in integrating AI-powered tools into the testing process. Despite these challenges, a systematic approach, as suggested by Sugali (2021) and Khaliq, Farooq & Khan (2022), enables organizations to unlock AI's potential, improving testing efficiency, and ensuring high-quality software.

In Sugali's (2021) study, AI models used in test automation may lack domain-specific knowledge, making it challenging to understand the context and significance of certain test scenarios. To address this challenge, it is crucial to ensure that AI models are trained on diverse datasets to capture the nuances of different testing scenarios. Additionally, domain experts can be consulted to provide guidance on the specific requirements and challenges of a particular testing scenario. Khaliq et al. (2022) mention that ensuring a versatile and representative dataset for training AI models is crucial. Gathering relevant data encompassing a wide range of user behaviors and system configurations can be challenging. To overcome this challenge, organizations should invest in collecting and maintaining a diverse and representative dataset to train AI models effectively.

The complexity of test automation, especially when integrating AI-powered tools, can pose challenges in terms of implementation and maintenance. To address this issue, it is essential to choose the right ML or DL algorithms based on specific testing needs and consider using pre-trained models fine-tuned for specific testing tasks. Bias and ethnic concerns related to the use of AI in test automation are important challenges to address. Additionally, organizations should establish clear guidelines and policies to ensure the responsible use of AI in test automation. (Khankhoje, 2024.)

Khankhoje (2024) also mentions in his study, that training the testing team on AI concepts and tools to effectively utilize AI-based automation is a significant challenge that

organizations need to address. To overcome this challenge, it is crucial to invest in training and development programs to equip the testing team with the necessary skills to work with AI-powered tools. The challenges of using AI in test automation are significant but can be addressed through a systematic and iterative approach. By addressing these challenges, organizations can harness the power of AI to improve the efficiency and effectiveness of their testing processes and ensure high-quality software.

3.5 AI based tools

Traditional test automation tools often require significant manual effort in test case creation, maintenance, and execution, leading to challenges in keeping pace with agile development methodologies. However, recent advancements in AI have revolutionized test automation by offering intelligent solutions capable of addressing these challenges. This section explores the AI-based tools for test automation, their capabilities, advantages, and applications in software testing.

Generative AI tools, such as ChatGPT, provide enhanced capabilities to create reasonable qualified content based on the prompts given by the user. ChatGPT is an AI-based conversational model developed by OpenAI that can be used in automating various tasks within software testing procedures. ChatGPT facilitates the automation of code generation and testing through the generation of structured data, code snippets, and annotations. This multifaceted approach streamlines the software development process by automating tedious tasks and enhancing efficiency. In test automation, ChatGPT serves as a versatile tool capable of streamlining various aspects of the software testing process through its NLP capabilities. In the Table 2 below is presented several ways in which ChatGPT is utilized in test automation. (Goar et al. 2023; OpenAI 2024.)

Table 2. ChatGPT's utilization in test automation

Feature	Description
Code Generation	ChatGPT can generate code snippets based on natural language prompts, facilitating the creation of test scripts and automation frameworks.
Test Scenario Creation	Testers can interact with ChatGPT to articulate test scenarios and requirements in natural language, which are then converted into structured test cases.
Code Completion and Correction	ChatGPT aids testers by providing code completion suggestions and correcting syntax errors in test scripts, thereby improving script quality and accuracy.
Documentation Generation	ChatGPT can generate comprehensive documentation for test plans, test cases, and test results, enhancing collaboration and knowledge sharing among team members.
Debugging Assistance	ChatGPT assists testers in diagnosing and troubleshooting issues in test automation frameworks by analyzing error messages and providing insights and recommendations.
Continuous Integration and Deployment (CI/CD) Integration	ChatGPT can be integrated into CI/CD pipelines to automate the execution of test scripts and analysis of test results, ensuring timely defect detection.

Overall, ChatGPT empowers testers to leverage natural language interactions for efficient and effective test automation, ultimately improving the quality, reliability, and agility of software testing processes. ChatGPT can be integrated directly to test automation frameworks to enhance test script generation and maintenance. Also, there are other similar tools available than ChatGPT, such as Microsoft Copilot and Google's Gemini. There are also AI-based test automation tools in the market, that are used to automate test cases. The amount of human involvement is minimal in these tools. Some examples of test automation tools that utilize AI are Katalon, Tricentis Tosca, Mabl and Eggplant (Gartner 2024a; Katalon 2024).

4 Research approach

This chapter presents the empirical part of the research and reviews the selected research methods. First, the goal of the research and the research questions are presented. Next, the choice of the research method is justified, and the data collection is described. Finally, the case company and implementation of the research is presented.

4.1 Goal of the research

The goal of the research is to find out how artificial intelligence is utilized in test automation processes. The purpose is to get information about the current status of artificial intelligence-based test automation in a case company. In addition, research aims at clarifying whether artificial intelligence has solved the current challenges related to software test automation and whether it has eased the workload. To achieve these research goals, the research questions have been formulated as follows:

RQ1: What is the current status of AI in test automation?

RQ2: How is AI implemented into software testing projects?

RQ3: What skills and tools are required?

RQ4: What are the limitations of implementing AI?

RQ5: How is the future of AI and test automation seen?

As the whole potential of AI is not utilized yet in test automation, the research questions aim at clarifying the current status of AI implemented in test automation. The goal is also to understand how AI can be applied to software testing activities, and what are the benefits and potential of it, and how the implementation of AI in software testing projects is done or should be done.

4.2 Research method

Qualitative research means research that examines a phenomenon without statistical methods or quantitative means. According to Goundar (2012), qualitative research uses words and phrases and is not based on numbers. The purpose is to describe, understand and interpret the phenomenon. Qualitative research is often descriptive, where the researcher is interested in processes, meanings and understanding phenomena with the help of words, texts and images. Interviews, that are used in this research, are one the most popular techniques for gathering qualitative data. (Ugwu & Eze, 2023).

Qualitive research was chosen due to the research questions that require open discussion around the topic, and because there is not enough evidence of the use of AI in test automation. The interviewees were selected based on their job description, and their suitability to be interviewed was first reviewed with a short preliminary discussion. For their work, the interviewees had to be aware of the use of AI in test automation, and the interviewees were wanted from different roles so that different perspectives could be brought out as comprehensively as possible. The challenge was to find suitable interviewees within the case company. Based on preliminary research, AI and its benefits to test automation are of interest to many, but the experience of utilizing it in software testing is not yet so comprehensive.

4.3 Data collection

The empirical part of the research is carried out with a qualitative themed interview. Qualitative thematic interview is the most common and important data collection method in qualitative research. In a themed interview, the topics of the interview, i.e. the themes, are typically known in advance, but the questions are not precisely organized or formulated. Instead of asking detailed questions, the interview proceeds based on the themes of the research. The advantage of theme interviews compared to other data collection methods is its flexibility in collecting data. Using a themed interview, the collection of data can be adjusted as required by the situation, following the interviewees. The thematic interview was carried out in a semi-structured way in the study. In a semi-structured interview, the

researcher has prepared some interview questions in advance, but space has been left for spontaneous discussion in the interview situation. (Myers & Newman, 2007.)

The theme interview is suitable for a research topic that is relatively new. Therefore, it is difficult for the researcher to know the direction of the interviewees' answers. A semi-structured thematic interview as a data collection method gives the interviewees the opportunity to talk about their experiences of artificial intelligence-assisted testing freely, so that information about the real benefits and challenges of the phenomenon can be obtained in a versatile manner. (Myers et al. 2007.)

4.4 Interviews and case company

The author of this thesis works as a test specialist, and the topic of this paper was chosen based on her job description and her interest in test automation and AI. The author discussed about the research topic with the case company and learned that the case company would be suitable for the research and there would be suitable persons for interviews. All interviewees were selected from the same case company, which is a Finnish consultancy company focused on the design and development of digital services. One of the case company's services is quality assurance and test automation. The case company has around 200 testing experts, of which five persons were selected for interview.

The search for interviewees began in the fall of 2023 when the research topic had been chosen. Before selecting the interviewees there were preliminary discussions about the situation of test automation and artificial intelligence in the case company, and about who would be suitable persons to be interviewed. Interviewees were selected based on their job description, and they had to have knowledge or experience on test automation and AI. The interviewees were selected from different roles in order to get as comprehensive view as possible. A short preliminary discussion on the topic was held with interviewees before the interview. Interviewees, their roles, experience in testing and the date of interview are listed in the Table 3 below.

Table 3. List of interviewees

Interviewee ID	Role	Experience in testing	Interviewed on
H1	Test Automation Developer	5 years	12.03.2024
H2	QA Consultant / DevOps Architect	18 years	18.03.2024
H3	Test Automation Capability Owner	10 years	21.03.2024
H4	Capability Owner for Testing and Test Management	20 years	25.03.2024
H5	Test Manager	15 years	26.03.2024

The interviews were conducted in March 2024. An hour was reserved for the interviews, and each interview was slightly different in structure, depending on the interviewee's background and role, even though the interview questions were the same. The interview questions were sent to interviewees in advance, so that they could familiarize themselves with the interview themes and find out the answers to the questions. The interviews were conducted in Finnish remotely via Microsoft Teams and face to face. The interviews were recorded using Microsoft Teams's record function. Recordings were transcribed, and the citations were translated into English.

5 Results

In the following paragraph, the main findings of the interview-based research are presented. Results are based according to the themes of the theoretical part of the thesis. The first chapter discusses the status of AI in test automation, followed by implementation of AI in software testing projects. Third chapter explains what skills and tools are required for TA and AI, and fourth chapter introduces the possible limitations. Last chapter discusses the future of AI and test automation.

5.1 Status of AI in test automation

The research question "RQ1: What is the current status of AI in test automation?" is answered in this section. The importance of artificial intelligence in test automation is constantly increasing, and in this section, the status of AI in test automation is explained at the time of the research. The expectations, demands and current capabilities of AI in test automation were discussed and impacts of AI were analyzed.

5.1.1 Demands and expectations of AI in test automation

According to the interviews, all participants experienced that currently the demands and expectations towards AI in overall are high. Interviewees' views on the role of AI in test automation vary, reflecting the range of customer expectations and the challenges of the technology development. In particular, there is an emerging conflict between expectations and reality, and a need for clarity and understanding of the potential and limitations of AI.

One observed trend from the interviews is that while some customers express a high interest in using AI in test automation, they still want to carefully consider its implementation and think about security issues before making a decision. On the other hand, AI is perceived as a potential tool for providing a quick and accurate review of issues, which can support decision-making and enhance the quality of information.

> "In a way, I think the function of quality assurance is to provide as accurate review of things as possible, so that the right decisions can be made as quickly

> as possible. In other words, QA must be able to provide a good overview of the quality and where we are going. So definitely AI should be helping with that, how we can provide better quality information, and faster." (H2)

However, it has been noted that customer expectations regarding AI may be overly optimistic, expecting it to solve all problems without sufficient understanding of its capabilities and limitations.

> "I believe that customers somehow mystically assume that AI is now so smart that it will solve all their problems, just because when you take the AI into use, the problems will disappear. And I think this is a huge challenge for us as a technology company to try to meet those expectations or to get the customer to understand what they can expect from AI and what it can solve for them." (H2)

There is uncertainty about the adoption of AI and a perceived need to experiment with different approaches. While the technology is evolving and offering new opportunities, many see challenges in integrating AI into systems and concerns about security and data usage as significant barriers.

> "Everyone is a little bit confused about what's going on. Everyone is waiting to understand, what is the best [way to utilize AI] in our context. Now is perhaps a kind of experimental phase and everyone is looking for situations where they could try [AI]. And I see this way that the generative big language models are now emphasized, causing a bit of a blind eye to the fact that there is a lot of other things, machine intelligence and artificial intelligence that can be applied, but the focus is now on the generative models. And I would see it this way that the focus in these generative models is because they are easy. Relatively easy to apply, relatively easy to implement. Its threshold is lower than the fact that you would create something like an own model related to test cases classification, which threshold is higher." (H3)

Moreover, while AI is expected to take over responsibility for testing and test automation as a whole, concerns about security and what data can be given to AI persist. Interviewee H4 mentions that there may not yet be a fully comprehensive understanding of the benefits of AI in test automation in Finland, and there are existing test automation tools that utilize AI available in some other countries. Interviewee H5 emphasizes that the lack of knowledge provides an opportunity for pioneers to change industry practices for their own advantage.

The discussions raised the following issues, that it seems that although the potential of AI in test automation is significant, there is still work to be done in terms of adoption and managing expectations. Establishing clearer understanding and guidelines regarding the role

of AI and the practical issues of its adoption could help customers and in leveraging the technology fully and responsibly.

5.1.2 Current capabilities of AI in test automation

The interviewees were asked to evaluate current capabilities of AI in test automation. All interviewees acknowledge the potential of AI, but they also mention its limitations in daily tasks. The importance of AI in data organization was underscored, and interviewees described that it is expected from AI to answers to questions like an oracle. They also highlighted AI's capability to summarize information or generate new insights based on existing knowledge.

AI's assistance in decision-making and content creation, such as generating test plans, test procedures, test scripts, and test data was mentioned in discussions. However, interviewees raised concerns about the maintenance capability of AI assistance. Interviewee H4 examines AI's role throughout the testing lifecycle, mentioning its involvement in various aspects:

> "In a way, if you think about the whole testing lifecycle, then of course the test plan, documentation, requirements, requirements analysis, building test cases based on requirements, for example, in different formats." (H4)

The availability of data was seen as an enabler for AI to manage the tasks. AI's ability to handle many tasks effectively, as long sufficient data is available for AI for guidance or training purpose was emphasized.

> "The question of what to leave out [for AI] is a bit like what to leave out for test automation. That is, things that are not repeated or for which there is no data available, or things that are very specific, that it's worth just having a human to go and find out and take care of them." (H5)

Overall, interviewees felt that currently AI can be only utilized in some of the test automation activities and saw a lot of potential on it, but it has still many limitations. They emphasized AI's role in organizing data, and AI's assistance in decision-making and content creation was highlighted, contingent upon the availability of sufficient data.

5.1.3 Impacts of AI in test automation

According to the interviewees, the impacts of AI in test automation is difficult to evaluate, because AI is not yet widely used. Most of the interviewees saw the potential of AI in speeding up the work related to testing. However, they emphasized the need for critical evaluation regarding the answers generated by AI and warned against blind acceptance without careful assessment of the answers.

AI was seen to assist particularly in creating test scripts and decision-making, but its value and adoption require further expertise and understanding. Interviewees felt that AI assists with test scripts and it can also be used in creating test automation plans based on existing test plans. Documentation can be made easier using genetic models.

> "What I've tried and used myself, if I start to write a python script related to test automation, and if I know roughly what I would like to do, but then it would take a lot of time to plan it, I have noticed that, for example, even ChatGPT gives pretty good basis and ideas to that what I should do. Of course, sometimes the answers are questionable, but when you just know how to ask the right questions, in my opinion there will be quite quickly quite good ideas. So, it speeds it up at least and helps with the groundwork." (H1)

However, there's a fear that AI responses may be blindly accepted without critical evaluation. All interviewees raised concerns about the need for critical evaluation of AI responses.

> "It seems that at the moment very few people stop to question what they get from the AI. I'm afraid it's just going to get to the point where what the AI says is interpreted as true and no one has the time to question it, nor the desire or the know-how to question what it says, and if it seems to work then maybe it's right." (H2)

Three of the interviewees felt that AI enables more efficient work, especially for juniors, and currently has significant positive impacts. However, according to two interviewees, the value produced by AI is still minimal, and its implementation requires expertise and understanding of its usage and highlighted the mastery of using AI. Also, they raised that the lack of internal company data limits the use of AI, reflecting the current limited benefits of AI.

> "The customer has not implemented the company's own AI instance where they can protect their own business. Thereby, they can't give any of business-critical data to AI. Then AI is just such a general questions assistant, i.e. you can ask for advice on how you would do something like automation or this type of stuff, but the actual data can't be used to teach AI, so it remains well as such a half-way, I might say." (H5)

In summary, utilizing AI fully in test automation requires further research and development, as well as careful evaluation of its suitability and potential applications. While AI was recognized for assisting in creating test scripts and automation plans, concerns were raised about its blind acceptance and the need for expertise in its implementation. Additionally, limitations in accessing internal company data were noted, impacting the extent of AI's usefulness in test automation.

5.2 Implementation of AI in software testing projects

The research question “RQ2: How is AI implemented into software testing projects?” is answered in this section. The utilization of AI in test automation was evaluated, and the potential of AI in test automation discussed. Also, the actual process of implementing AI to testing projects was explained and the benefits of implementing AI in test automation was considered. Finally, integration of AI to test automation frameworks was evaluated.

5.2.1 Utilization of AI in test automation

The interviewees considered various activities in which AI is utilized in test automation. Some interviewees find the use of AI in test automation still limited and challenging, while others see it as already more deeply integrated into the testing process. All interviewees see the potential of AI in test automation and mention its ability to speed up the testing process and provide valuable assistance in test planning and error detection. According to most of the interviewees, AI is used in test planning to create test cases and investigate error situations. Although AI can be asked what to test and help with testing activities, it mainly function is seen as a digital coworker that you can ask things along the way. Training a customized model can provide more comprehensive benefits across different phases of testing. If AI is integrated into test automation framework via an interface, it can already provide valuable answers. However, generating test data with AI remains challenging, as it can only generate basic data.

> “If you think about the whole testing lifecycle, then of course the test plan, documentation, requirements, requirements analysis, creating test cases based on the requirements, for example in different formats. And on the test design

> side, the API interfaces can be used, for example, to connect to the test automation tools and create those test cases.” (H4)

Interviewee H1 mentions that they are using AI currently in code design, writing, error detection, and correction. However, its usage is still limited and requires proper questioning to receive useful responses.

> “Probably just writing and designing the code. There's probably a lot of other things to do, but I haven't really experimented much myself in the end. If you think about the whole test automation aspect, it has just gone to the direction where I'm asking the AI for code scripts or things like that. And help with finding bugs - I'll enter the code snippets [to AI] and ask: "what's wrong with this?".” (H1)

Two interviewees mentioned also, that additionally, if a test automation case fails, AI can suggest how to correct the code. They also mentioned AI-based tools that track test automation coverage in code, analyze code changes, and check whether automated tests cover the modified areas or need updating. Also, AI's value in measurement and investigative testing was highlighted, as it can bring new ideas about what to test.

> “It can be used, theoretically, to maintain tests. If there are any small changes in the code, [AI] would be able to detect it, that what has changed and then [AI] would change it [in the test automation code]. And also including the guidance of testing performance or impact analysis, that when software development is done in a specific area, then to analyze the areas where usually could be bugs after the changes. [AI] can address those areas, which need new test automation development, for example.” (H5)

All interviewees emphasize the need for the right expertise in using AI in test automation and mention that its use requires a certain amount of learning and understanding. Many interviewees mention the need for caution in applying AI in test automation and highlight that its use requires careful consideration and the right approach.

5.2.2 Potential of AI in test automation

The potential of AI in test automation was seen as significant because AI is evolving at such a rapid pace. Interviewees perceived that the potential of AI is especially in test data generation and utilization, code and data analysis, test case creation and prioritization, and test control, as AI can track code changes more effectively than Big Data currently allows. Also, potential was seen in assessment of test coverage, and prioritization ensures that the

areas with the highest likelihood of bugs are tested. AI can also optimize computing power usage, thus enhancing sustainability.

> "I see its potential everywhere, it speeds up the start, or whatever phase is ongoing, if it involves any kind of writing or other kind of manual work. To speed up and of course it can also explore, perhaps getting quick answers if you feel that you have some problems in any of your work, then maybe it can give you some ideas, when you are blinded to what you are doing. That it can find relevant points then. Kind of like a "buddy", with whom to go through things." (H1)

> "Data analysis, that's absolutely essential. But we would like to get to the point that AI also starts to control the testing. We must somehow link it to the changes. But I see that it is very doable thing." (H2)

AI was seen to be also used to create regression tests when there is enough data available. It was also seen beneficial for UX and giving visual overviews of testing status. Visual comparison was also mentioned, where AI monitors changes made to the interface.

> "For example, how the user uses the system and based on that, for example, [AI is capable of] creating regression tests." (H4)

> "If we wanted to test UX with AI in some way, and if we would have enough data mass about how people use the web interface to get behavioral patterns from it, and what can then be applied to automate usability testing. But this is probably there far away." (H3)

> "I hope that it would be able to give some kind of visual insight into the overall overview. We would be able to easily get some kind of analyses that how big part of our application we have now tested or where our focus is on testing. Or learn, for example, if we have a web application, that what is the human behavior on the page, that we will find those important critical parts of what needs to test more." (H2)

Additionally, interviewee H3 highlights the potential of AI in analyzing test automation data and test maintenance. H3 also discusses AI-assisted self-healing automation, where tests are automatically corrected. This represents a more advanced utilization of AI than what two other interviewees mentioned in the previous question. The possibilities of AI are widely seen in data analysis and finding connections – the more data available, the more benefit. Interviewee H5 believes that companies should develop their strategic thinking regarding AI and create interdisciplinary teams to identify areas where AI can be used. Regarding testing, especially from the perspective of test automation, AI has great potential in root cause analysis, which helps identify the most important areas to be tested. AI's potential is seen also in availability of data wherever it is needed:

> "After all, the problem is that the silos between companies also cuts off the flow of information, so if AI could overcome such and sort of silo points in a way that would allow the AI to swirl with the data between many different parts of the organization, then this is probably one of the big benefits and here the testing is one part of the chain, and it should produce the information that can then later be used at a slightly higher level." (H5)

Some barriers were also raised before the potential of AI can be leveraged. Legal challenges and data classification are key issues to address before wider adoption of AI.

> "These interesting questions which I think are now starting to raise more as there are more and more opportunities. For example, this legislation and how to classify test data or company material, and in which categories they can be given to AI and in which not. It is the next interesting big discussion, that there is the potential, but now we should be careful not to reveal too much." (H2)

Overall, interviewees recognize the potential of AI in various areas of test automation, such as design, test data generation and analysis, test control and prioritization, and user behavior and test result analysis. The necessity of data for everything was emphasized; the better AI can handle data, the more potential there is for leveraging AI in testing. AI has a wide range of potential in test automation, and the scope and focus of its use may vary depending on how the organization uses it and the needs it is intended to address.

5.2.3 Benefits of implementing AI in test automation

All interviewees perceived that the greatest benefit of AI in test automation is to speed up testing and increase testing efficiency. Additionally, ideation, support in documentation and performing manual tasks were frequently highlighted during the interviews.

> "Using [AI] to support in documentation and in brainstorming. And giving ideas to exploratory testing scenarios." (H4)

> "When you have the data, you can do anything a lot faster and, for example, give data to AI and say that "here are the old test cases, do similar ones now for these areas"." (H5)

> "You get more efficient and effective testing, you get more out of less, you get it done faster. Less human resources needed for maintenance, better test coverage. Faster, in a shorter time cycle, the whole testing process from design to reporting and fewer bugs. I think that when the systems become more complex and it is no longer necessarily a single supplier but an ecosystem of suppliers, we can better control larger entities of this kind. Systems with larger architectures can be better managed." (H3)

Acceleration, increased efficiency, the ability to feed data to AI, and automating test cases based on data was also underlined. With sufficient data available, AI can perform many testing tasks, and automation tasks exceptionally well. If it can be trusted that data can be safely fed to AI, the benefits can be nearly limitless.

The interviewees were also asked to provide an estimation on how much time does AI save time in test automation, if any. They did not provide any concrete estimates of how much time AI currently saves in test automation or manual testing, as there is limited evidence. Some interviewees felt that AI could save some time in testing, such as bug fixing and ideation.

> "I don't have any estimates. All customers are cautious about [implementing AI]. Everyone is basically only at the proof-of-concept stage. I haven't seen the actual implementation anywhere. My prediction is that the same thing will happen than with test automation, it may change more likely people's job description than remove people from the equation. That is, roles and titles will change." (H2)

> "If you look at our customers, I would say that at the moment we are not so far that we could [evaluate], because everyone is still in the pilot phase. But now that we are in the hype peak, they say that there is up to 60% of the coding benefit. But I do not believe them, they are just marketing bullshit, and that the realism will probably come when the promises and quality will find the right balance." (H3)

However, others believed that more time is spent going through, verifying, and correcting the answers generated by AI.

> "It depends so much on whether you are using the own instance where you can use your own data. I don't think it really speeds up that much yet." (H5)

> "I don't think it saves time, it seems to me that it takes more time than it saves, as it's really only now being studied and built." (H4)

In summary, there are varied perspectives on the time-saving potential of AI in test automation, with some expressing optimism about potential savings while others are more skeptical, emphasizing the need for further real-world implementations and assessments.

5.2.4 Process of implementing AI in a software testing project

Interviewees shared insights into the implementation process of AI in test automation, highlighting the stages and possible considerations. Some had experienced that the process

lacks clear definition, and decisions were made informally without direct guidance from the management. They felt that the implementation process begins with training staff on prompting and leveraging AI and selecting suitable AI model.

> "It depends at what level, but first of all, of course, you should train people in basic prompting. And then you have to choose the AI model, or language model, to be followed and implemented. And connect the AI probably with some API interface to the tools that are used. Then the level at which [the AI] is allowed to use the data is decided. And then after that it's really about what is wanted to be achieved, whether it does documentation or test cases or what." (H4)

> "Well, there hasn't been any direct prohibition. It's probably a bit circumlocutionary, or I don't know how high up this [decision] came from when it was made." (H1)

According to the interviewees, the initial phase involves evaluation, hypothesis testing, and result assessment. They emphasize the crucial stage of data processing and preparation. Following this, ML engineers can start planning how to apply the data to use cases. They also mention, that while clients are interested in AI, there are no concrete implementations yet.

> "Customers have many hypotheses about what they would like to achieve [with AI], but in my opinion, this is still in its infancy, and we haven't even dared to go to the challenging stage of what to do when we need to use the data. So, everyone is just in the process of who dares first." (H2)

Interviewees were also asked that how and who decides which testing activities AI is implemented to. AI has not been widely utilized in projects yet. The common view from interviewees was that decision to use AI originates from the top from e.g. security reasons, but one interviewee highlighted that individuals decide how they use it.

> "In practice, the customers decide the top level [of how AI is used], but then each test automation developer decides for their self, and then they use AI as much as they feel necessary. I don't know if most people currently use ChatGPT or some other similar tool on a daily basis, but I know a few people who do." (H1)

> "I have not seen yet own AI strategies or who decides. It's usually top-down, if you want to get some kind of consensus at the beginning when you decide something." (H2)

> "I would see the hierarchy so that if you start from the top, so probably the [customer's] chief architect determines these policies, with which artificial intelligence and machine intelligence is used. The policies come from the top, that the organization in question applies. Of course we [consultants] have to follow them. Then there's probably a quality directive of the client which

> guides how they apply them and then the QA managers decide on how they apply [AI] to that project." (H3)
>
> "The decision must come from the top, particularly due to the security issues. Who will take it to use or how it will be used. There must be someone who knows something about AI. They all tend to focus on the fact that they should know how to handle data. A person who then looks at what and where it can really be useful because someone must validate the outputs." (H4)
>
> "I think it should be done at the level of company management, so that the biggest benefit would be achieved from AI. Of course it can be done as an experiment, that is, think about starting from a certain area, for example, testing and test automation, but even then, before that company's management should have a clear understanding of what kind of limitations and what kind of opportunities it has, because the more it would be used in general, the more there should be understanding of how it can be used. In my opinion, its development should be lead just like anything else. In a way, implementing AI would be like a change project, that it would be worthwhile to put it into practice by means of a change project, and that's a really big job for a change project. There are so many different things that need to be considered. But it is probably the way it should be done. It should get people involved and should get people to learn from the old and should have a vision of where we are going and should be measured to see how it can be measured and whether we are going towards the desired change." (H5)

The responses underscore the importance of data handling and the need for a clear plan before implementing AI. Decisions should be made at the executive level, with leadership playing a crucial role and change management being essential for successful implementation.

5.2.5 Integrating AI to test automation frameworks

Interviewees were asked to comment on how easily can existing test automation frameworks integrate with AI technologies. Interviewee H1 has utilized Python as automation tools and received good ideas from AI. H1 experimented with both paid and free versions of ChatGPT and noticed significant differences, particularly due to the newer database used in the paid version.

> "I may not have tried [AI with] so many robot tests yet, but for Python I have received a lot of ideas. I have also asked some questions with PHP Javascript and it has worked reasonably well." (H1)

Interviewees H2 and H4 believe that success with AI lies in using open-source test automation solutions or well-established ones in the market. For instance, with Robot

Framework, they observed that most language models can provide fully executable test cases without additional assistance, thanks to the abundance of educational materials available for the framework.

> "In my opinion, the absolute key to success is these open-source solutions or other solutions that have been on the market for a long time. For example, with the Robot Framework we see all the time the fact that when there is a tool which code and discussion are all in the public web and these language models have learned all the answers and discussions about it, and also the code solutions. We have actually compared 4 or 5 language models and almost every language model is able to give a fully executable test cases with Robot Framework with a single prompt without having to help more. I argue that it is precisely because it is so public tool, and it has been in the teaching material included in what these models have been taught." (H2)

> "Those public open-source solutions are easier to integrate, because there's so much more data available and output is probably reasonably correct already." (H4)

Interviewee H3 finds that integrating AI technology like ChatGPT into test automation frameworks is feasible through APIs. However, achieving deeper integration into their own test automation framework is also possible but requires more effort.

5.2.6 Impacts of AI on test automation results' quality and reliability

Interviewees perceive the impacts of AI on test automation results' quality and reliability depending on whether they use AI at work or not. They felt that AI can impact test automation both positively and negatively depending on how well it's utilized and trained.

> "I think it's a bit like 50/50. At least at the moment that either it can have a very positive effect or depending on whether you know how to write the right questions and train it to understand what you're looking for; it can also generate really bad answers." (H1)

> "At a general level it definitely helps and when we get that data, we will certainly get out of it some patterns that we can't see with the human eyes and brains and that will help us find that new uncharted areas. But also, then the fact that we can combine different data domains to each other as the source code, results, test cases and these then form some kind of analysis results." (H3)

Most of the interviewees express concerns about AI's potential negative influence on the quality level or were not able to comment on this as they felt that practical effects have not yet been observed widely.

> “Well not so far, because I haven't seen it used on a large scale. I still fear that it will decrease the quality and then the other bad side that is not in testing, maybe more so in development, that it kills innovation, it flattens everything. So, if there exists a problem, it is everywhere. It is as a security risk, that the solutions will be too similar. They can be exploited in the same way then. But I have not seen [the use of AI] in practice, and I cannot say how it affects.” (H2)

> “Not really, but if we would use it at the moment, it might have a negative effect.” (H4)

> “It probably doesn't have much of an impact at the moment because it hasn't been taken into use.” (H5)

5.3 Skills and tools

The research question “RQ3: What skills and tools are required?” is answered in this section. As using artificial intelligence effectively in any task requires knowledge of how to use AI, the required skills for testers to effectively work with AI was determined. Also, the responsibility of individuals and teams for acquiring these necessary skills was compared. Finally, the AI tools were discussed.

5.3.1 Required skills for testers to effectively work with AI

In interviews, all participants highlighted that the most essential key skills are prompting and source criticism for leveraging AI in test automation. Also, test automation skills were underlined.

> “The first skill is to understand your own area, what you're doing, what testing is, but after that you should be able to prompt, or you should be able to understand what you want to ask.” (H5)

> “Data, data processing, data rules and the fact that “garbage goes in garbage goes out”, that in a way that what goes in there what comes out of there, the critical analysis and evaluation of what it produces. You should have a lot of knowledge so that the end results really are useful.” (H4)

> “You should first of all have a good basic knowledge of the subject [that you are utilizing AI to] in terms of practical and theoretical level just because if you use this kind of AI tools, and knowing that AI can answer anything [true or false answers], so if you cannot criticize what it answers, I would be a little concerned from a data security point of view, if you use the answer in the

> project. You should understand that the answer is generated by AI, and it is not the absolutely right answer always." (H1)
>
> "Programming is absolutely the number one in TA, but perhaps I think it is precisely the most important thing to find what are the most suitable languages to use with AI, and for example OpenAI has a lot of complete libraries for Python, which is a common language. So, then the language should be chosen correctly." (H2)

Also, the eagerness to follow technological development and to learn new things was highlighted in the discussions to be one of the most important skills for test automaton developers.

> "It seems that it is a bit forced [for TA developer], that in these development phases when all these new tools are developed, whether it is AI or not, so if you do not boldly go to try these things out, you fall out pretty quickly from the development. That is the future, that you must be interested in such things." (H1)

Interviewee 3 highlights data engineering and data science skills, that are important for benefit of AI:

> "But also if we are talking about things like this, when I have ChatGPT and then I have my own model alongside it, so maybe then it will come to the fact that if we are a testing service provider of our own model of data input and selections then it will probably be such data engineering and data science skills, because we must then respond to [our customer] organizations and their AI policies. And the other thing is if we want to integrate some AI through an API interface, so of course the integration skills." (H3)

While all interviewees agreed on the importance of skills like prompting and critical thinking, some focused on programming skills, while one interviewee highlighted data-related competencies. Additionally, selecting suitable programming languages for AI-supported tools was highlighted and the need to train AI in the right direction for desired outcomes.

5.3.2 Acquiring necessary skills for implementing and managing AI in testing

The interviewees held differing views on whether learning the necessary skills for using AI in testing is in the responsibility of teams or individuals. They felt that learning could happen internally within the team and through self-study. They emphasized the team's responsibility to onboard others and help them get started. Additionally, experienced members should highlight both the risks and benefits of AI usage to others.

> "If someone wants to start using AI in the team, I think that the responsibility is on the members of the team who have the expertise [on AI], assuming that there is expertise, and they help to familiarize others with AI if necessary. I think that the responsibility of bringing up the benefits and risks is on someone that is more experienced too, so that you know then what you are about to do. Everyone is responsible for their own learning." (H1)

> "I assume that it is mainly now this kind of self-motivated exploration and then we have a few experimental projects, so there's probably maybe a little more done systematically. They revolve around ChatGPT, and of course what could be the learning path so of course the basic understanding that what is AI, and what are the categories there and what are the methods by which to create those." (H3)

Interviewee H2 strongly believed that learning new skills is the team's responsibility, not individuals'. It is crucial for the team to ensure that all members are at the required skill level and support individual development and learning when necessary. Additionally, interviewees mentioned the potential benefit of learning skills with AI testing certifications, training sessions, workshops and sharing information internally. Interviewees H4 and H5 did not see a single correct approach, recognizing that people learn differently. H4, however, felt that skills ultimately come from individuals to organizations.

> "I feel like there's no one way because people are different. But surely it should come through individuals to organizations. And, of course, like any other skill, certainly not everyone can do it in the same way as someone else. That must always be considered according to the situation, but because then again if we talk about data that is, however, its own discipline. In a way, who has skills for it?" (H4)

> "We should invest in [AI and the necessary skills to be able to use it], because now there is quite a lot of the phenomenon of people running alongside the wheel, so to speak, and not being able to jump on it." (H5)

As all the interviewees thought from the consultant's perspective, learning is also constrained by the prioritization of client work, which takes precedence over their own learning of new skills. They also suggested integrating learning into the company's operational model, possibly under the responsibility of business units. Also, the importance of investing on acquiring the skills was seen necessary.

5.3.3 AI tools

The interviewees discussed about the AI tools used in test automation. All of them mentioned language models and copilots, that are in the spotlight now, such as ChatGPT and Microsoft Copilot.

> "Absolutely language models and copilots, or the language model is behind the copilots, but in a way, in my opinion, of those that are available now, that is, let's say integrated copilots, or those that are used directly from the websites of their providers." (H2)

> "Microsoft Copilot and ChatGPT, they appear to me. I use them for [test] management tasks." (H5)

Interviewee H1 found ChatGPT's paid version beneficial for supporting test automation. H1 also noted that the versions of ChatGPT and the language used (English or Finnish) influence on the responses generated by the AI.

> "Now that I have the paid version of ChatGPT, there's actually more than just the prompting, I should take some time at some point and explore all the other features that are there. And then there are other AI tools in mind. Mainly those that are available or do not require some payments, I am eager to try those and compare that how much those then have differences. I have done well with this paid version of ChatGPT." (H1)

Also, OpenAI's development of a language model for a graphical user interface was mentioned in the discussions. Interviewee H4 identified AI-powered test automation tools such as Tosca, Mabl, Eggplant, and Code Intelligence. However, interviewees H2 and H3, expressed uncertainty about the real benefits of AI-based test automation tools on the market.

> "Well, I guess we are probably still in the beginning of all [with AI-powered testing tools], so I think they are more like blurry so far. The AI is just a term used to sell more, and it is a bit of a question mark that are there any benefits of it." (H3)

Interviewees mentioned that currently they are mostly using virtual copilots at their work.

5.4 Limitations of implementing AI

The research question "RQ4: What are the limitations of implementing AI?" is answered in this section. There are many things to consider before taking any new technology, as AI, into use in software projects. Therefore, the considerations of integrating AI into testing systems

were discussed, as well as ethical and security issues of AI. Also, regulatory challenges and other barriers of using AI in testing were explained.

5.4.1 Most common concerns when integrating AI into legacy testing systems

All interviewees believed that AI tools can be integrated into various systems, including legacy testing systems, if the appropriate permissions have been given. Also, the interviewees felt that the potential of integration depends a lot on the system's code base. They felt that the major challenge of integration of AI is that the quality and structure of code in old systems vary, raising questions about whether models like ChatGPT can support old code.

> "As long as you can somehow control the inputs and see the outputs, you can [test with AI] at some degree. But then, of course, is the code base as well controlled? Then whether it is such a code base, which is, for example, in ChatGPT's model enough to get even something support it." (H3)

> "If we go all the way to the DP2-world or other similar, then the problem is that they are also so closed systems that there may not be that much information available, but then on the other hand, they are so old that there is certainly some information of e.g. Mainframe, that can be found. Thereby, everything is based on the fact that is there up-to-date information available and then again if you think about something like the Mainframe environment, there is certainly enough information that can be used to create a basic test plans, scenarios and test cases etc. Of course, then comes the question of how much, and then that what is today's legislation of Finland compared to then certain systems, e.g. Mainframe." (H4)

Interviewee H2 perceives that old and complex systems are particularly suitable for leveraging AI because they often contain a large amount of data that AI models can quickly assimilate. H2 emphasizes the importance of considering costs when contemplating different solution options. In AI solutions, costs may suddenly escalate with usage. H2 specifically highlights the significance of AI costs at different stages:

> "When AI is integrated into the [testing] process, can the AI update the automation process as well? Because using it is expensive, if it is used in the design work, then it is a one-time cost. You pay for it as you design, but if the AI is involved in every daily automation run, it becomes very expensive." (H2)

In summary, interviewees highlighted the challenges posed by the closed environments of old systems for AI and the difficulty of accessing up-to-date information from them. Sufficient information about the system is necessary to effectively utilize AI.

5.4.2 Ethical considerations of implementing AI in test automation

The interviews revealed varying viewpoints on ethical considerations and practical concerns regarding the implementation of AI in test automation. The importance of transparent communication with clients and cautious handling of sensitive data to maintain trust and mitigate risks was emphasized.

> "Of course, our own company will guide us on how we can use the [AI] tool. But then if you go to the customer and would like to use tools of this kind, then you should first discuss there at the customer's end, that how they see this. I think transparency is an important aspect of that and that we have then a kind of responsibility of it, if we know about the use of the tool, we should bring up the risks too. Would it be a common policy that if the customer gives permission so that it would then be more of this kind of generic use. We should be careful not to enter customer data, but it could be used as a tool to speed up the work, for example, or whatever the policy is." (H1)

Interviewees H2 and H3 highlighted the ethical implications of AI, particularly regarding fairness and accountability in decision-making, especially when utilized by less experienced testers.

> "If the educational data hasn't been right, how it favors certain things. Perhaps in test automation, I'm not so much concerned about ethics, as I am about accuracy. The fact that how we go along with the hallucination sometimes and trust blindly, for example, if we let AI to do usability testing, whose responsibility is that it thinks the usability is really usable for people that use it? And it is interesting that when it is seen that is a tool for juniors to produce senior's end results, so are those juniors then able to evaluate AI in these aspects, that if [AI's results] works and looks good, so do they go with it then?" (H2)

> "Even if it were using our own AI model, then how biased it is or the degree, how well the data engineering or data science has done its own groundwork and then whether it guides the decision-making or automation in the right direction. And then, of course, when we create test data, we often use production data, does AI use that kind of data, which is in the possession of, for example, GDPR or business secrets or something similar." (H3)

Concerns about intellectual property rights, data security, and potential biases inherent in using generic AI models or developing proprietary ones was raised. Ethical considerations regarding data selection and privacy were also emphasized.

> "Does it also then also reduce the skill of thinking, for example, when doing testing, and you ask AI to make a test plan for you, so can you then after a while do it anymore [by yourself]? I think if we say that we are experts in

> testing, then we should not lose those basic skills by having someone that makes it easier for us." (H3)

Interviewee H4 expressed apprehensions about AI's ability to discern real data from synthetic data, posing significant security risks, and the need to carefully manage AI usage to avoid overreliance and resource depletion. H4 also questioned the sustainability of using AI in everything.

> "The ethics is fed there already, and then it depends on how you use it, whether you can avoid those things? That is perhaps the difficulty in it. Well, of course, if someone makes a mistake and they enter there some real data, even real customer data, then the AI cannot distinguish it from the synthetic data. And then when you know that there have been fed more and less intentionally e.g. material from internet. Then there may be a little too much real data. And then all these sustainability issues, that is also related to ethics in how much [AI is used]. Do I ask every single thing from AI, when it takes quite a lot of resources." (H4)

The impact of training data on AI's understanding and the possibility of cultural biases influencing AI outcomes and ethical dilemmas arising from potential misuse of information were also discussed.

> "As for the data being used for teaching, I think it's kind of the teacher's own vision. So, I mean the person who has given the data, the understanding of AI is distorted that I suspect to be pretty much such like an American person, which is emphasized there." (H5)

Overall, while interviewees acknowledged the benefits of AI in test automation, they underscored the importance of addressing ethical and accountability issues to ensure responsible and effective implementation. The person using AI should be aware of the potential ethical problems of AI.

5.4.3 Security aspects of AI

Security aspects of AI is an important thing to consider, in addition to ethics, when implementing AI in testing. Interviewee H1 emphasized the importance of avoiding the input of critical customer data into AI systems, suggesting the use of code snippets devoid of sensitive information. Interviewees H2 and H3 expressed concerns about the risks associated with data manipulation and the potential for malware embedded in AI models to pose security threats. H2 further highlighted the possibility of AI recommending dependencies containing vulnerabilities, posing significant security risks.

> "Of course, these own [AI] models are their own asset, and those security is on the same level as the security of any of their own data asset. Then, of course, the data security is also related to the fact that when we have some data collection and when we do the data engineering and the data science in it, we need to analyze whether it is poisoned data. Whether it is, for example, an external party intentionally poisoned by making API-calls with the wrong data and you use it with the poisoned wrong data then in your analyses." (H3)

Interviewee H3 emphasized the need to maintain a balance between synthetic and authentic data and its impact on AI's behavior, while also highlighting the importance of ensuring that AI models are as secure as other data assets. Authentic data is created by humans, and synthetic data is generated by AI, and doesn't exist in the real world (QuestionPro 2024).

> "The balance of synthetic data and authentic data is going all the time to that direction where we have more and more synthetic data, so I've been thinking about the question of at what point comes the pivot point? At what point does the amount of synthetic data start to affect the output of the language model, for example? And actually, research has been made, that it flattens it, because based on the fact that there are many differences in the original data, so it flattens the number of differences, thereby flattering even more then the quality of the output. And at some point, comes the point where the model crashes and the model cannot produce any added value anymore." (H3)

The importance of data protection and preventing AI from making erroneous conclusions that could lead to hazardous situations was also underscored. Interviewees emphasized the importance of considering of security issues in AI implementation, alongside ethical considerations, highlighting the need to avoid inputting critical customer data into AI systems and the risks associated with data manipulation.

5.4.4 Regulatory challenges or compliance issues of AI in testing

Interviewees highlighted the variability in the application and acceptance of AI across industries, suggesting that different sectors and clients may have distinct regulatory to utilizing and embracing AI technology. Interviewee H2 emphasized the significant challenge posed by the lack of regulatory guidelines regarding AI, although some organizations are beginning to develop their own protocols. However, there remains a general lack of understanding regarding AI regulations.

Interviewee H4 discussed the forthcoming EU-level regulations concerning AI and the existence of national guidelines in countries like Sweden, contrasting Finland's current lack

of similar regulations. These regulations typically address issues such as cybersecurity and plagiarism prevention. Also, concerns about the absence of regulation potentially stalling innovation were raised, and differing regulatory practices across countries was seen as a challenge. Additionally, interviewee H5 suggested that the slow adoption of AI might be caused by the lack of understanding of its capabilities, with many companies prioritizing security concerns over AI implementation due to perceived risks associated with sharing data.

> "And then it's a bit of a messing around, that there are many people who are enthusiastic about AI, but then when [AI] is not part of the company's strategy, it doesn't make any progress. And therefore, customers hope that others would bring the required information to their companies, and I think that there are two major things to consider, the safety and the other is what benefits AI brings. The bigger the benefits the better, and it should be rather business benefits than technical benefits, and then management would be interested." (H5)

5.5 Future of AI in test automation

This section answers the research question "RQ5: How is the future of AI and test automation seen?". At the moment, the use of AI is only at low level in testing, and not all the benefits of AI are yet to be realized. Therefore, the future of AI in test automation was discussed from different perceptivities, and the pain points of AI in test automation were identified.

5.5.1 Estimation of when AI is utilized in test automation

The interviews provided diverse perspectives on the timeline for full utilization of AI in test automation. For example, H1 suggested a timeline of 5 to 10 years for full implementation, contingent upon the availability of necessary components, with major tech companies likely leading the way in adopting AI. Contrastingly, H2 proposed a shorter timeline of potentially 5 years, citing the ongoing AI hype and rapid technological advancements, especially in language models. According to H2, early adopters will pave the way for wider acceptance.

> "I think the hype has been so high so quickly that all these language models are only a few years old, so I'd be really surprised if AI would not be really well [in use] in 5 years' time. I could argue that it would only take a few years,

> that we need the first ones to dare to follow and then everyone will dare to follow, but that we are so close." (H2)

H3 envisioned a timeline of 2 to 5 years for full utilization, dependent on the maturation of generative models and the development of tools and processes to the required level. H4 offered a more immediate outlook, suggesting that AI could already be partially utilized in test automation within a year, with ongoing experiments, particularly in cybersecurity. Finally, H5 predicted a timeline of 1 to 2 years, after companies are willing to share their data with AI, contingent upon their views on business opportunities and development prospects.

> "I think that in one to two years, after companies are willing to share their own data, then it depends on the company how they see the business opportunities, development opportunities, acceleration opportunities, but those who see it, they will certainly start to do it quite quickly and it is not just for test automation, but it is in many other areas as well. The test automation is part of a larger entirety, and frankly I don't believe that testing or test automation alone are big enough to make it explode, but it should be part of a larger entirety." (H5)

5.5.2 Prospects of test automation and AI

The interviews provided varied perspectives on the role of AI in test automation, ranging from its function as an assistant to its potential as an autonomous tester. Interviewees emphasized AI as a tool to support human testers, with humans retaining a crucial role as ethical guardians. Despite AI advancements, human oversight remains essential to ensure ethical conduct. Interviewee H2 envisioned AI primarily as an assisted AI rather that augmented AI in the future, not yet capable of independent decision-making but rather supporting human decision-making processes. Interviewee H3 suggested that while the nature of the work may change with AI, test automation developers' roles are unlikely to disappear entirely.

> "I don't think [testing by humans] is going to go away. I'd say that basic testing will maybe become a bit of a bulk business. But then again, the question raises that how we test those AI models themselves and the related quality concepts. Perhaps the focus will then shift to these." (H3)

AI was mostly seen to be more as a tool and support system in test automation, acknowledging that its utilization can vary across organizations and individuals.

Contrastingly, one interviewee foresaw AI revolutionizing test automation but remained skeptical about its ability to autonomously conduct testing tasks.

5.5.3 The pain points in test automation that AI could help with

The interviews were asked to describe the most critical pain points, that they assume that AI can help with in the future. Interviewees highlighted AI's role in addressing initial challenges in task initiation, prioritizing test cases, providing innovative problem-solving ideas, and helping with complex bugs. Also, they emphasized AI's ability to increase test automation coverage, manage complexity, and improve speed in finding relevant issues.

> "I think it's about increasing test coverage and solving the complexity. Or helping to manage the complexity and speeding up testing. More and faster and the right kind of things." (H2)

Interviewees discussed AI's potential in standardizing documentation, generating negative test cases, and test data, thereby facilitating test planning and diversifying testing approaches. Interviewee H5 outlined AI's assistance in integrating longer chains within a company, leveraging data for business purposes, accelerating test automation development and maintenance, and easing test planning and documentation. Additionally, AI could enhance the utilization of data produced by test automation within companies.

6 Discussion

The aim of the thesis was to study how artificial intelligence is used in test automation and what advantages it brings. The thesis aims at answering to the research questions: What is the current status of AI in test automation, how is AI implemented into software testing projects, what skills and tools are required, what are the limitations of implementing AI and how is the future of AI and test automation seen.

Artificial intelligence has been in growing hype recently and efforts are made to utilize AI in all fields, and especially to facilitate manual tasks. AI is utilized in many phases of software development processes, testing and test automation being one part of it. AI is constantly developing, and work is being done in testing and test automation to ensure that all potential is released. As AI is a trending topic, it was easy to find related academic resources for the theoretical part of the thesis, although the use of AI seemed to be much more widespread in the literature than in the research of this thesis. The research compares how AI is used in test automation in the case company, and what is the potential and limitations seen for it. The study included five interviews with experienced software testing professionals. The key findings of the study are presented below, answering the research questions. As this research and interviews are done for a specific case company, the results reflect the situation of the company in question, and the results cannot be interpreted to be universal.

6.1 Key findings

RQ1: What is the current status of AI in test automation?

The study shows that AI is not yet as widely used in test automation as the theory suggests, but the benefits of AI are seen as having great potential. Expectations and hopes for AI are high, but there is still a fear of experimentation, waiting for someone to be brave enough to be the first to deploy AI, so that others will have the courage to follow. Many people want to understand more about AI, and they are concerned about ethical and security issues before they dare to give critical data to AI. The results show that people expect a better understanding and clearer guidance on how to use AI. The study also shows that people

using AI need to critically evaluate the answers that AI generates, and that AI cannot be used for testing everything.

RQ2: How is AI implemented into software testing projects?

Results depict that AI is mostly used to assist in some of the testing activities and data analysis, but a lot of potential is seen for AI, as AI is evolving at a rapid pace. According to theory and interviews, AI can be used in the future in all test automation activities as presented in the Figure 4 below.

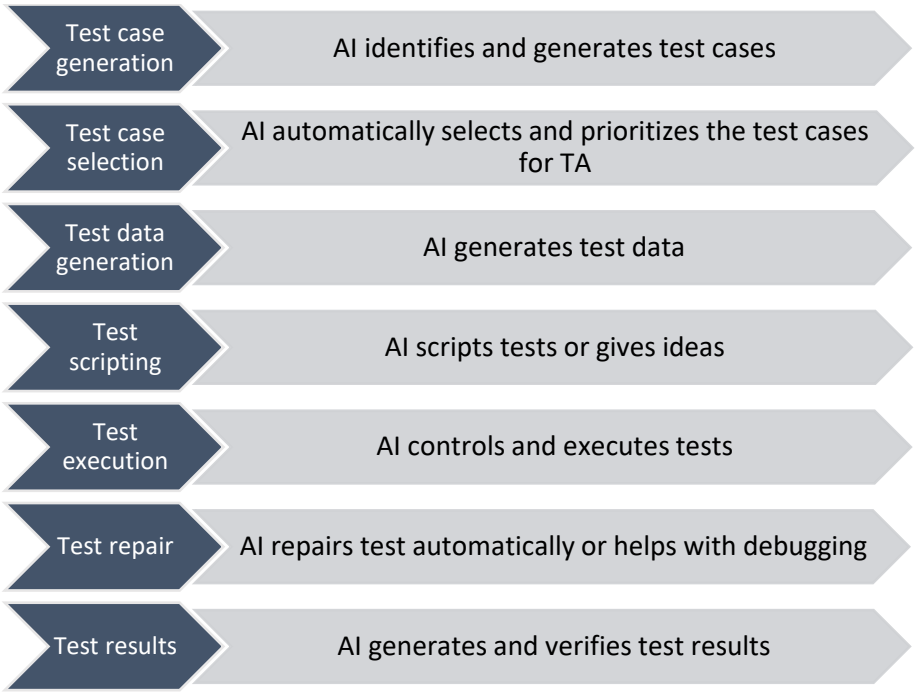

Figure 4. Potential of AI in test automation activities.

The difference between theory and results was that, according to theory, AI can already be used at all these stages of test automation. Based on the interviews, AI is currently mainly used in test scripting and test planning tasks only, and everything else is seen as a future potential. The results highlight using open-source test automation solutions with AI to achieve the best outcome. According to Rafi et al. (2012), test automation cannot be used for UX testing or exploratory testing, but according to the results, the interviewees also saw potential of AI in regression tests, UX testing by visual comparison and giving ideas to exploratory testing. Thereby, AI can provide new testing methods to test automation if AI can make extensive use of data.

According to results, speeding up testing, increasing testing efficiency, documentation and ideation were seen as the greatest benefits of AI in test automation. In addition to these benefits, Trudova et al. (2020) also highlights the elimination of human-like errors as benefits of AI. Nevertheless, no significant difference was seen in the results in terms of time savings or impacts on quality of the test results if AI was used, rather it was feared that more time would be spent to verifying and correcting the answers generated by AI, even though time savings were one of the main benefits of AI according to the literature. Research shows that to benefit the most from AI, companies should make a decision at the top level to use AI and make a plan how AI is used, and the adoption of AI should be led and monitored, similarly to other change management processes. Theory also supports the argument in the results that AI should be invested in order to benefit from it.

RQ3: What skills and tools are required?

Khankhoje (2024) mentions in his study, that training the testing team on AI concepts and tools to effectively utilize AI-based automation is a significant challenge that organizations need to address. According to the results, most relevant skills for leveraging test automation and AI are prompting and source criticism, not to forget the basic test automation skills. The eagerness of following and trying new technologies was seen as essential for TA developers. There was a disagreement on how to acquire the necessary skills to the individuals or teams. Some interviewees felt that the responsibility is on individuals, others saw that it is on the teams. Virtual copilots, such as ChatGPT and Copilot were seen as the most popular AI tools in the daily use, but a few AI-based test automation tools were also mentioned.

RQ4: What are the limitations of implementing AI?

Results show that security issues and ethical considerations are the most critical issues of implementing AI. Concerns about feeding critical data to AI were a major barrier to its use, and data is needed for AI to produce the most useful results. The interpreting of AI's answers is important, as it may favor certain answers or visions. The "garbage in, garbage out" mindset also came up several times in the interviews, i.e. what is fed to the AI directly influences to the AI's outputs. Also, the code base of the system under test, and the availability and quality of data affects how well AI can be used. Sugali (2021) also emphasizes the lack of domain specific knowledge in AI models as a challenge. To address this challenge, AI models should be trained, which was also mentioned multiple times in the

results. One important finding was that the use of AI can also undermine people's own creativity and thinking, and this is something that should definitely be taken into account if AI is used on a daily basis. Additionally, sustainability issues should be considered, using AI for everything uses a lot of resources.

RQ5: How is the future of AI and test automation seen?

According to results, it is estimated that AI will be utilized in test automation within 5 years. Some interviewees speculate that the timeline would be up to 10 years to full implementation of AI, and some interviewees saw that it could happen within 1 to 2 years already as the hype of AI is such high already now. Results show that AI is expected to have a huge positive impact on test automation, although it will not replace testers. AI was seen to assist in test automation, rather than autonomously perform testing. Lack of information and information chains within companies were seen as a pain point where AI can help.

In summary, the aim of this thesis was to compare the theory collected from the resources with the data collected from interviews in the case company; how AI is used in reality and how AI is implemented in testing projects. It can be said that the results support the theory in many respects, but the main difference is the use of AI, which is actually much lower than the theory suggests. There are still many unanswered questions about the regulations, security and ethics of AI. Felderer et al. (2023) introduces 4 levels of autonomy of AI in testing, and according to the results we are only at level 1, where AI algorithms assist humans by performing automate testing tasks.

6.2 Limitations of the results

The results answered the research questions as expected. The study provided insight into how the case company currently views the status of AI and test automation, how it is currently used, what the limitations of AI are, and what its potential is perceived to be. However, there are also limitations of the results. All interviewees were selected from the same case company, limiting the range of perspectives of the results. Therefore, the results reflect the situation of the company in question, and the results cannot be interpreted to be universal. Also, as there were only five persons interviewed, the results of the study correspond to their visions and the results may differ from the broader sample. The

interviewees' backgrounds and roles were taken into account to ensure that the results were as diverse as possible. However, because the case company operates in the consultancy sector, employees often have insight into the ways of working and thinking of many different companies, which reinforces the reliability of the results.

The status of AI is changing very rapidly. When viewing the results of this study, it must be also taken into account that the results describe the situation in March 2024. When this topic was chosen for the thesis in the autumn 2023, there was not yet much practical experience of using AI in test automation. Now, during the past six months, things have progressed quite a lot, and the situation might be totally different next autumn or in a year from now. For example, Gartner (2024b) forecasts that 80% of enterprises will have integrated AI-augmented testing tools into their software engineering toolchain by 2027.

7 Conclusions

The aim of this thesis was to answer to the research questions: What is the current status of AI in test automation, how is AI implemented into software testing projects, what skills and tools are required, what are the limitations of implementing AI and how is the future of AI and test automation seen. First the resources of the subject were studied, and the research questions were pre-defined. Secondly, the theoretical part was written, after which the interviews were held. The results are based on five interviews, that were conducted in March 2024. All interviewees were selected from the same company, and the results reflect the situation of the company in question.

Artificial intelligence has been in growing hype recently, and the expectations of it are high. There is a desire to use AI in all areas, including testing and test automation. The results of this study can be used to get a general overview of how AI is currently being used in test automation. If you are considering the use of AI in testing, this study provides a good basis for what to consider before implementing AI.

The results support the theory in many respects, but the main difference is the use of AI, which is actually much lower than the theory suggests. A huge potential is seen for AI, but currently it is mostly used to assist in some of the testing activities and data analysis. AI-powered tools are seen to enable the automation of code generation, code review, bug detection, and testing processes. This allows TA developers to dedicate their efforts to more complex software development endeavors, thereby enhancing overall productivity. According to theory and interviews, AI can be used in the future in all test automation activities, but it was seen that AI will be only assisting in test automation, rather than autonomously performing testing. One important finding was that the use of AI can also undermine people's own creativity and thinking, which should be kept in mind when using AI on daily basis. Results show that AI is expected to have a huge positive impact on test automation, but it will be not replacing human test automation developers.

The study provided insight into how the case company currently views the status of AI and test automation, how it is currently used, what the limitations of AI are, in addition to what its potential is perceived to be. The study also answered to all research questions. However, there are also limitations of the results, as there were only five interviewees, and all the

interviewees were selected from the same case company. Therefore, the results cannot be interpreted to be universal as the results reflect the situation of the company in question.

This study provides a basic understanding of how AI can be used in test automation. Because AI is currently evolving rapidly, there are a huge number of other research opportunities around this topic. The status of utilization of AI in test automation can be completely different in a year or two, compared to March 2024, when the research of this study was carried out. Also, sustainability of using AI in test automation is an important subject, that could be investigated much more.

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Appendix 1. Interview questions

1. **Background**
    - Role and description
    - Experience in software testing / test automation
2. **Current status of AI in test automation**
    - What are the demands or expectations from customers/projects regarding AI in test automation?
    - What are the current capabilities of AI in test automation?
    - How do you perceive the impacts of AI in test automation?
2. **Implementation of AI in software testing projects**
    - In which test automation activities AI is currently utilized?
    - To which test automation activities AI can be potentially implemented?
    - What are the benefits of implementing AI in test automation?
    - How much is AI currently saving time in test automation, if any?
    - What is the actual process of implementing AI in a software testing project?
    - How and who decides to which testing activities is AI implemented to?
    - How easily can existing test automation frameworks integrate with AI technologies?
    - Analyze how AI influences the methodology of test automation and its impact on results' quality and reliability?
3. **Skills and tools**
    - What skills are essential for testers to effectively work with AI in test automation?
    - How are teams currently acquiring the necessary skills for implementing and managing AI in testing?
    - What AI tools are/would be used?
4. **What are the limitations of implementing AI?**
    - What considerations need to be taken into account when integrating AI into legacy testing systems?
    - What ethical considerations arise when implementing AI in test automation, especially in sensitive industries or applications?

- Analyze security aspects of AI.
- Are there regulatory challenges or compliance issues associated with the use of AI in testing, especially in industries with strict regulations?
- What are the primary factors impeding the implementation of AI?

5. **Future of AI in test automation**
    - When is it estimated that AI is fully utilized in test automation projects?
    - How is the future seen for test automation and AI?
    - What are the pain points in test automation that AI could help with?