Topic 1:

Title: Building a Metamorphic Testing Tool: Investigating Existing Approaches and Developing a tool prototype

Supervisor: Alejandra Duque-Torres (alejandra [dot] duque [dot] torres [at] ut [dot] ee)

Metamorphic testing (MT) has emerged as a promising approach for addressing the oracle problem in software testing, where the expected output for a given input is unknown. In MT, metamorphic relations (MRs) are used to identify the relationship between input and output, which can be used to generate test cases automatically. The aim of this thesis is to investigate existing approaches for the automatic generation of tests using the MT approach and identify their limitations. The thesis will explore ways to overcome these limitations and develop a new tool that provides test cases, including source and follow-up inputs, given a set of MRs.

The thesis will begin by conducting a comprehensive survey of the current state-of-the-art in MT tools and techniques and identify the strengths and weaknesses of existing approaches. This will involve studying the implementation details of existing tools and evaluating their performance on at least one application domain. Based on this survey, the thesis will aim to develop a novel tool that can generate effective test cases using MRs.
The developed tool will be evaluated on the chosen application domain, and its effectiveness will be compared to existing tools.

Topic 2:

Title: Developing a User-Friendly Visualization Plugin for Metamorphic Testing Logs

Supervisor: Alejandra Duque-Torres (alejandra [dot] duque [dot] torres [at] ut [dot] ee)

Metamorphic testing (MT) is an effective approach for addressing the test oracle problem in software testing, where the expected output for a given input is unknown. However, one of the biggest challenges in MT is selecting high-quality Metamorphic Relations (MRs). While some techniques have been proposed for automatically selecting MRs, they often work under strict assumptions or focus on specific domains.

To address this challenge, we have proposed a method that selects and constrains MRs based on test data. This method involves three stages: generating random test data using a fuzzer, transforming the test data based on the MRs, and generating logs that record information about inputs, outputs, and any MR violations during the execution of the test data and transformed test data against the System Under Test (SUT).

This thesis will focus on developing a user-friendly visualization plugin for the logs generated by the proposed MR selection method. The plugin will provide a summarised view of the logs, enabling users to quickly identify MR violations and other critical information about the

SUT. The plugin will also allow users to interact with the logs, visualizing different aspects of the test data and MRs.

The thesis will begin by conducting a thorough analysis of the MR selection method and the logs generated by it. The student will then design and implement the plugin, considering factors such as user experience, ease of use, and compatibility with existing MT tools. The plugin will be evaluated through user studies, comparing its effectiveness to existing visualization methods.

Topic 3:

Title: Metamorphic Mate: Building a Tool for Automated Metamorphic Relation Discovery, Querying, and Visualization

Supervisor: Alejandra Duque-Torres (alejandra [dot] duque [dot] torres [at] ut [dot] ee)

This thesis is an extension of the approach we are proposing, where we have already established a comprehensive set of metamorphic relations. Our approach is based on the idea of using test data to select and constrain MRs, which has been identified as a significant challenge in the metamorphic testing field. The approach comprises three main stages: generating random test data to the SUT using a fuzzer, transforming the test data based on the MRs, and generating logs to record information about inputs, outputs, and any MR violations during the execution of the test data and the transformed test data against the SUT.

However, with a large set of MRs, filtering and querying them based on the SUT and domain knowledge can be a time-consuming and error-prone process. Therefore, the aim of this thesis is to develop an automatic tool that helps with this process.

The main objective is to enrich the existing database of metamorphic rules and create a user-friendly system that allows easy querying and visualization of the filtered rules. The tool will enable users to specify SUTs, filter rules based on the SUT and domain knowledge, and view the results in a summarised and interactive manner.

The proposed tool will also provide the functionality to add new metamorphic rules to the database by leveraging techniques such as machine learning and data mining. Overall, this thesis will provide a valuable contribution to the metamorphic testing field by facilitating the creation, querying, and visualisation of metamorphic rules based on our approach.

Topic 4:

Title: "Translating Metamorphic Rules from Natural Language to Test Code using AI APIs like Chat GPT in Forms of Templates"

Supervisor: Alejandra Duque-Torres (alejandra [dot] duque [dot] torres [at] ut [dot] ee)

Metamorphic testing is a technique that can enhance the effectiveness of software testing by verifying if a program's behavior remains consistent when its inputs are changed in certain ways. To generate test cases automatically, metamorphic testing requires a set of metamorphic rules. However, expressing these rules in a way that is easily understandable for developers is a challenging task.

Typically, metamorphic rules are provided in the form of natural language descriptions, making it difficult to convert them into executable test code. This thesis aims to develop an AI-powered approach that can automatically translate natural language descriptions of metamorphic rules into test code templates. The proposed approach will utilize an AI API, such as Chat GPT, to generate these templates.

The thesis will start by exploring the current state-of-the-art techniques used for metamorphic testing and their limitations. It will then delve into the details of natural language processing and how AI APIs, like Chat GPT, can be employed to create templates for metamorphic rules. The study will also investigate the types of metamorphic rules that can be translated using this approach and evaluate the performance of the proposed method.

The expected outcome of this thesis is a novel approach that can translate natural language descriptions of metamorphic rules into test code templates using an AI API like Chat GPT. The proposed approach can benefit software testing practitioners by reducing the manual effort required for writing metamorphic rules and enabling them to focus on other critical aspects of software testing.