Description for the general public

One of the most commonly used objects in computer science is a tree – data structure that represents more complex data than strings and models hierarchical relationships between objects such as organization structure of a company or our family tree. That is why it is important to analyze problems on trees and **the main goal of this project is design of efficient algorithms and analysis of hardness for problems on trees**. I'll investigate particular problems on trees and analyze them from two points of view: upper and lower bounds.

The first direction of my research aims at **finding efficient solutions** for specific problems. Usually, our aim is to construct an algorithm that computes the correct answer and simultaneously works fast. It's hard to compare the effectiveness of algorithms without actually implementing them, so we consider so-called time complexity, a measure of efficiency which – to some extent – helps us estimate, how big data can be processed by our algorithm in a reasonable time, say a minute. Then we know, if we can run it of tens, thousands or millions of elements. Such information is very important if we are chemists or biologists working with huge data because it might turn out that our exact solution is not able to process them even in a year! Then we need to look for another approach that returns an almost optimal solution but always works fast. At the same time we need to guarantee that the found solution is not much worse than the optimal, say by a factor of 20%. So, if the algorithm is fast and we can guarantee that the solution it found is not much worse than the optimal one, we call such an approach approximation algorithm. I will design such algorithms during the project as well.

Another direction of my research is the **analysis of lower bounds** for hardness of problems. This is more challenging because it requires us to show, that **no** algorithm can solve the problem fast, not only these that we already know. Fortunately, it's not impossible. Recently scientists started investigating relationships between problems and showing that some problems are not harder than some others. If we now suppose that some of the very well-known classic problems cannot be further improved, we can state so-called **conditional lower bounds**. These are conjectures which say that one problem cannot be solved fast, unless we can improve on some classic problem, which seems to be impossible. Because of that, such statements provide new insight into many problems and relationships between them. That is why I would like to further develop this area.

In the beginning of the project, I will consider the problem of **Tree Edit Distance**. In this problem, we are given two trees and ask what is the minimum number of insertions or deletions of a node to transform one of the trees to the other.

To sum up, the goal of this project is a systematic study of different problems on trees. I'll mostly focus on the worst-case complexity so expect the results to be of theoretical nature. However, I believe that this will allow us to better understand real-life problems which will help to improve currently used techniques.