Navigation of people or cars is a problem, that was tried by solved for years to gain an advantage. Finally, the outdoor navigation had been solved by the GPS technology. Unfortunately, the GPS signal is mostly unavailable inside building leaving the indoor navigation problem still open for other solutions. The lack of comercially applied solutions to self-localization and indoor personal navigation makes it a perfect subject of research with potential practical applications. There is a need for such solutions as often people visiting an unknown building are lost and need to ask for directions. It is indifferent, whether it is a public building like any department, museum or shopping centre. Working solution to presented problem could lead a person to a goal using the shortest path or could present interesting information regarding the current location.

The problem of indoor navigation is also an open problem in robotics and computer science, especially when the autonomy for agents navigating in the environment is required. Mobile robots perceive a world using a set of sensors like RGB-D sensor (e.g. Kinect), laser scanners or encoders providing the information about wheel movement. A mobile robot, that can efficiently localize itself in its working environment can perform also other tasks, e.g. be a guide in the museum or support people in their work.

To achieve a precise localization indoors, it is necessary to efficiently process information from available sensors, regardless whether it is a personal navigation with smartphones or a system designed for mobile robots. The only difference is a set of sensors available in both cases that result in different methods that are used to process those information. When the information is extracted, there is a need to fuse the information from different sensors and in both cases it is possible to apply a method based on graph representation of location constraints. In that factor graph method, the nodes of the graph represent the pose of an agent (person or robot) in the environment. The edges, that connect two nodes, correspond to the difference in agent poses measured by a sensor.

The graph can be understood as a system of connected springs (graph edges), which are joined together in places representing the graph nodes. When the system is left without any external force, the springs would appropriately squeeze or stretch until the system is stabilized in the equilibrium. Similarly, the factor graph, the optimization process is used to find agent poses in the environment that best explain the measurements taken from sensors. Unfortunately, the presented method works only with measurements, that can be represented as a distance in metres between two agent poses. In cases, when the sensory information cannot be represented in that way, it is not possible to use that information in factor graph for localization purposes. The exemplary non-metric information, called also qualitative constraints, are the observations that two agent poses are in close vicinity, or that it is impossible for two poses of an agent to be closer each other than a given distance. It is worth noticing, that there is a huge variety of information clues that can be used. What is important, people mainly use the qualitative information for localization -- in most cases the person is capable of determining its own location with respect to some object, but cannot tell the metric distance to that object. Therefore, the main goal of the proposed project is a development of methods enabling the use of qualitative information for localization purposes.

The project goals include also verifying how the inclusion of new, qualitative information in the graph affects the possibility to detect wrong measurements in the graph. Even though, the newest algorithm and the best sensors are used, the measurements taken in real-life conditions are uncertain. The goal of the analysis is to alleviate or reduce the impact of the measurement, which imprecision causes that the whole system is less precise that in a case without that measurement. In order to develop that method, we plan to analyse the behaviour of the factor graph during the optimization and make appropriate decisions regarding the mentioned edges (e.g. to inactivate them).

The last step of the project is the verification of the proposed system. Firstly, the tests in controlled conditions of the indoor locations inside Pozna\'{n} University of Technology is planned. The controlled conditions allow to further refine the proposed method in real-life situations and will inform about the precision of the system due to the use of external system used to estimate the localization of the agent. After the successful tests in the controlled environment, the next steps will involve the verification of the system for the mobile robot and person with a smartphone in an environment of the potential application -- shopping centre. The project results will be important in many aspects.

The project results include new methods to extract qualitative information, new methods to use that information for localization purposes and the data set that will be gather to test the proposed system that can be used by other researchers. The additional gain of the proposed project is the development of a system that merges the experience gained by the scientists from the robotics community, and by the people working on indoor personal navigation.