The introduction of the robotic arm in the early 1960s was an important step towards automation of industry. Much of the noisy, dangerous, and repetitious labour at assembly lines and blast furnaces could now be performed by a robotic operator instead of a human. The robots were very often individually calibrated and programmed each to perform their specific task – tasks which were now performed faster than ever, and without risking fatigue or injuries.

However, despite the increased productivity, the improved safety, and the standardised output, the robots lacked crucial skills which the earlier human operators possessed in great measure – flexibility and adaptability. In contrast to their human counterparts, the robots were highly stationary and fixated to their workspace, often bolted to the floor or at best moving along short rails, and even minor changes to their task specification required a complete reprogramming and thus time offline.

Over the past half century, efforts to endow robots with flexibility and adaptability have been major themes in robotics research. The work in this thesis is a part of those efforts, and deals with an important sub-problem called Simultaneous Localisation and Mapping (SLAM). Algorithms for the SLAM problem use data which the robot acquire from its sensors (sonar, laser range finders, cameras, wheel encoders, …) to determine and keep track of the surrounding environment. In other words, the robot has to create a model of its surroundings (the mapping part), and use it to determine its own position (the localisation part) relative to the model. This type of algorithms is necessary in order to enable mobile robots to move autonomously – that is, without a human operator actively controlling the robot.

Only in the last two or three decades have cameras become a realistic choice of sensor to use for robotic navigation. There are three major reasons for this. First, digital cameras have become available, and they have gone through a revolution in terms of both reduced price and improved quality. Secondly, computing power has continued to double approximately every second year, as predicted by the celebrated Moore's law. Thirdly, during
this time, there were many milestone advances in computer vision, which provided practical methods for inferring geometry from images. In this thesis I have considered the case of a camera mounted rigidly onto a mobile robot platform that moves across a planar floor, and directed in such a way that the images mainly contain the floor. By keeping track of how certain observed points move in the images as the robot moves over the floor, it is possible to deduce how the robot has moved. If the observed points on the floor plane are visible in two different images, their coordinates in the the two images are related through a transformation called a homography (see Figure 1). A homography between two images can be determined in a standard way from at least four pairs of corresponding points in the two images. One part of my work is concerned with extracting motion information from such homographies, and this is done by deriving a mathematical expression for the homography in terms of a number of motion parameters, and then solving for the parameters. My conclusion for this part is that the parameters can be determined reliably and efficiently, and that therefore the robot motion can be inferred from the floor images.

Homographies constitute a very general class of transformations, and by using the conventional method of finding the homography, one is not guaranteed to find a homography that actually is compatible with the assumptions one has made - planar camera motion and constant tilt (rigidly mounted camera). One part of this thesis considers the problem of finding a homography with those additional assumptions met. The way I solved this problem was to formulate those assumptions as so called polynomial constraints, and then using those polynomial constraints when devising a new method for finding a homography. My findings for this part of the work are that it is possible to find a homography which is compatible with the assumptions of planar motion and constant tilt, and that this can be done using only three pairs of corresponding points (compared to four, in the standard method).