There is an increasing interest in the development of autonomous mobile robots capable of solving tasks outside the classical industrial environment. A key component for autonomous behaviour is the use of perception systems to perceive dynamical changes in the environment while the robot moves around. Critically, a commercial robot has to remain safe despite failures in the system. When safety is addressed in the context of perception, it however often requires the introduction of ever more complex algorithms, which carries an intrinsic risk of inexplicable failures. This especially is an issue for autonomous robots, because of algorithms such as neural networks that are increasingly used for surveying and identifying obstacles in the field. Therefore, safety should be addressed to ensure the functionality and safety of the product in all phases. A common example of such processes are functional safety standards, which impose requirements on specific procedures and methods to utilise which improve reliability and safety of the robot. Functional safety is unfortunately not a matter of following a recipe, it is therefore important to have tools to enable the creation of standards-compliant safety for mobile robots.

In this thesis, we focus on a specific subtype within mobile robotics, called field robots. Field robots are robots for outdoor tasks in domains such as construction, forestry and agriculture. We investigate field robots in the context of agriculture, motivated by the increased need for efficiency and safety, stemming from the decreasing work force in rural areas. Even in highly developed countries, field operations contain many dangers to people and animals. Nevertheless to employ autonomous field robots in agriculture it is required that the system can operate safely.

The research in this thesis is rooted in interview and literature studies. This is to gather information from both industry and academia on how safety is achieved. Functional safety has a high focus within industry; to study this we conducted interviews with practitioners of functional safety and developed a case study of certification for a commercial camera based sub-system for automatically hoeing of weeds. In contrast, for academia we rely on a comprehensive literature study to map and understand how standards and safety within different robotics domains are used.

To facilitate the certification of autonomous robots and address the challenges of safe perception systems, this thesis presents a rule-based programming language for enforcing the safety of sensors with an explicit focus on cameras and computer vision. The language is referred to as the Vision Safety Language (ViSaL). This language is high-level and allows the developer to enforce safety constraints during implementation. ViSaL enables this through the specification of rules to ascertain quality and safety throughout a vision pipeline. As an example, rules can consist of simple vision algorithms individually or in combination, to obtain a quality measure for the specific point in the perception pipeline. The reason to use ViSaL is that it is designed to generate restricted code from general purpose programming language to increase safety. This approach is experimentally evaluated in connection with an artificial neural network called YOLO to understand the costs and benefits of using ViSaL. We see that the overall performance of the system is increased while improving the reliability in the system. A key motivation of using ViSaL lies in facilitating certification, where reviews of documentation and the program code should be done. Reviews entail that certifiers read and understand the intent of the code. A clear communication between developers and certifiers is needed. We therefore conducted an investigation in the evaluation of program code readability using ViSaL, resulting in improvements to the language.