Chapter 1

Introduction

1.1 Welcome

This text is intended for bachelor students of applied informatics who are following the course *Algorithms for AI Robotics* at Comenius University. These notes may also be useful to other interested students and individuals who share interest both in Artificial Intelligence and Robotics.

Artificial Intelligence is a field of Computer Science that has generated many novel and some useful ideas throughout more than 50 years of research, often interfering with and perhaps spawning new fields that are now considered independent, such as artificial neural networks, logic and functional programming, search, multiagent systems, or evolutionary algoritms. Thus it is often difficult to say what is still AI and what is already outside of its boundaries. Many researchers would have different opinions on that. Similarly, some may not like the term Artificial Intelligence, and rather use Computational Intelligence instead, in particular those coming from the engineering background. Yet other researchers with strong background in psychology, filosophy, or neuroscience have deep interest in studying human intelligence and cognition and its relevance for a machine or other man-made cognitive systems. We abstain from taking any strong position on this, rather try to take the best from all the areas that are relevant to building physical machines that can "think".

Although AI is a much more general field, at all times it has been looking at how its theories and methods could be applied to produce actual physical intelligent beings or devices, robots. Looking from a different viewpoint, Robotics is the latest stage of the industrial attempt to make the manufacturing free of human labor, starting from mechanisation, continuing on towards automation and robotics. These are two rather different approaches. AI researchers study questions as what is intelligence, based on what principles it works or could work, how one can represent various kinds of knowledge, how to reason about the environment, space, time, other agents and their intentions, how to select actions, communicate, predict, plan and prioritize, cope with uncertainty and unknown environments. On the other hand, industry is interested in precise and highly reliable, durable and productive devices that perform actions on demand. However, as the automation in factories advances, more and more operations and tasks remain for robots, including those, where complex decisions need to

be taken, problems solved, and where certain level of intelligence is required. It is thus the right age for joining the efforts, forming interdiciplinary teams and getting inspired by each others' ideas and results.

The course does not make any specific assumptions on preliminary knowledge, although some mathematical and programming background is needed. The described methods and algorithms are not always described in complete detail due to the limited time, space and available manpower, but we always refer the reader to the litetarature, where he or she can learn more. And it is always not our aim to explain all the details, rather provide a broader overview and explain principles. Interested students are recommended to continue their studies on selected topics further on!

The text is arranged into chapters in the order of the course lectures. As such, it serves as the reading material for the course and hopes to explain and support the topics being covered at the lectures. Since this is the first version of the text, it will grow and change throughout the semester, please always use the latest version that you find at the course website.

We plan to cover a wide range of topics. We will start with introducing the basic concepts of Robotics and Artificial Intelligence to develop our vocabulary and understand the issues at stake. This includes the main elements and challenges, different representations of knowledge. Having seen that, we cover the various styles of learning, and see examples of algoritms for each method, some of which we will study in more depth. We will study some aspects of building successful robotics architectures. We will also learn about probabilistic approaches to robotics, its applications and some theoeretical background. This includes methods of localization, navigation. We will try to understand some basic aspects of processing a visual information, even though it is a very complex field. We will dedicate one chapter to educational robotics as it has an inspiring value also for the AI. We will study examples of animal behavior that might be inspiring for a roboticist. We look into issues of multi-robot systems. Finally, we will look at some examples of successful robotics applications. The reader is always recommended to consult the refered papers, and perhaps books, they are listed in the bibliography at the end of the material, and refered from the text.

1.2 Robotics

Robotics is an advanced and multidisciplinary field. It requires expertese from mechanical engineering and physics, material science, electrical engineering and electronics, signal processing, control theory, mathematics, computer science and engineering, and many other areas. Robots are among the most complex systems a man has ever produced. The word robot, coined by the Czech writer Karel Capek, is now widely used all over the World, and generally means a man-made device that has a physical body, and that can move in its environment while performing some actions in it[1]. The robots move with the help of moving

[1] In wider sense, robots do not have to have bodies. For instance, search engine robots that crawl the Internet do not have bodies while they "move" in the network from a node to node and collect all available information. However, we will only consider robots with a physical body here. Even if the body exists only in a simulator, it has (at least some) properties of a real physical body. In that case we are talking about a simulated robot, or a simulated robot

parts - *actuators*. These are either motors, or selenoids, or some other parts that can generate movement, like artificial muscles, for instance. Most robots also sense their environment. For that purpose, the robots use *sensors*. We will talk more about the motors and sensors very soon.

Apart from pure curiosity and fun, people build robots to serve a particular purpose. In most cases, the robots replace people at workplaces, where the work is physically too demanding, boring, harmful or dangerous. Robots may also be used when they can do the work more accurately and reliably, and when they reduce the overall cost of production[2]. The applications of robotics are numerous, the following list names the most important ones:

Industrial robots - are robots that are usually mounted in factories on a production line, next to a conveyer belt that brings unfinished products from one robot to another. Each robot is responsible for performing a very specific operation, very fast, very pricise, very many times over and over in a repetitive fashion. This includes welding and screwing operations, painting, packaging, palletizing, pick and place operations, assembly, inspection, sorting and separation, and many other tasks.

Entertainment robots

Educational robots

Service robots

Delivery robots,

Monitoring applications

Medicine

Rescue operations

Scientific research and exploration

Defence

It is typical for industrial robots to operate in deterministic and static environments, i.e. in environments where the actions occur only in predictable order and where things do not move unexpectedly. In these scenarios, robots perform various operations, such as move an arm to a certain position. In many cases, the system is controlling some control variable (such as the power applied to a motor propelling a conveyer belt), and knows what should be the resulting behavior (such as the speed of the belt). The relation between the controlled variable and the actual output of the system may be complex and non-linear and thus it can not be computed directly. Therefore, the control engineers have developed a large family of controllers that deal with such situations. A notoriously known representative is a PID controller, depicted in the figure.

1.3 Artificial Intelligence

model.

[2]Note that this may seem to be a negative effect at the first glance. When robots are introduced, many jobs are lost and the levels of unemployment rise. However, application of robots typically reduces the production costs and thus people may be moved to safer, better, and more interesting workplaces. Just imagine how much work there is remaining in educating the mankind, science and research. How many people we would need in there! Thus the question is rather that of a correct distribution of resources than that of preventing the robots to be applied and used in production.

Bibliography