The role of machine learning in the development of robotics design

Machine learning can be regarded as one of the currently major parts of the research in robotics (Mosavi & Varkonyi, 2017, p.8). The trend towards the application of machine learning in robotics design is no coincidence, as machine learning can be regarded as highly suitable for robotics: In robotics, many problems exist where designing a precise algorithm is not the goal (Mosavi & Varkonyi, 2017, p.8), but it is rather about learning general behavior patterns. For this purpose, designing the software with machine learning algorithms can save significant resources because the software does not have to be programmed manually anymore (Connell & Mahadevan, 2012, p.1). Furthermore, machine learning can make robot software more generalizable and thus allow for operating the robots in changeable or only partially known environments (Connell & Mahadevan, 2012, p.1). For example, a particular robot should be capable of exploring unknown terrain, such as on Mars tor the deep sea. In such a situation, it is hard to program a robot without knowing which problems it will face (Connell & Mahadevan, 2012, p.3). The same advantage of learning applications does also exist for less sophisticated solutions: For example, if a vacuum cleaner robot learns the layout of the household it cleans, this is way more efficient than a robot where you have to enter the layout yourself (Connell & Mahadevan, 2012, p.3), or a robot that does not even know the layout and only drives around at random. In the case of a vacuum cleaner robot, learning is especially suitable because it can learn that objects can move, enabling the robot to efficiently re-route in case changes to its environment happened.

Of course, there are also problems and limitations to the application of machine learning for robot design.

One crucial data source for robots are sensors, as this is the only data source available to a robot as long the data is not hardwired to it from the start (Connell & Mahadevan, 2012, p.4). However, sensor noise can be a significant problem, because most cheap-to-build robot sensors are unreliable (Connell & Mahadevan, 2012, p.3), meaning that either one needs to invest in high-cost reliable sensors, or you are training your machine learning model on qualitatively questionable data. Therefore, knowing the problems of your sensors and being able to cope

with the errors they might cause (e.g. by probabilistic averaging, Connell & Mahadevan, 2012, p. 3) is crucial to building a successful machine learning model in robotics.

One main characteristic of machine learning based solutions are nondeterministic actions of the robots, meaning that actions will not always have similar effects. For example, if a robot picks up an object, it might be successful sometimes, but other times it fails to do so (Connell & Mahadevan, 2012, p. 3). This also means that machine learning might not be the right choice for the design of certain robots, e.g. in production lines where you want your robots to perform certain predefined tasks with high precision where there is no room for errors by the robots.

Another issue with machine learning in robotics is reactivity: For many applications, the algorithm has to allow the robot to act quickly, meaning that every step of the algorithm must not need a significant amount of time (Connell & Mahadevan, 2012, p. 3). Similar limitations apply to the training time, and the fact that a robot has to collect experience for a certain task implies that any reasonable learning algorithm must be incremental (Connell & Mahadevan, 2012, p. 3).

The problems with machine learning do not stop with those technological problems, but are further enhanced by more practical problems that can harm the development of the field. For example, people need to build trust in the machine learning application to adopt it (Siau & Wang, 2018, p. 47), what can be a serious problem, e.g. when it comes to self-driving cars.

All in all, machine learning in robotics can be regarded as a very interesting field with a lot of potential for developing robotics software quickly and at low cost, and even with functionality that you could never reach via traditional programming. However, at the same time, there are some serious limitations to the application of machine learning in robotics. Because of those limitations, you need to consider on a case-to-case basis whether for a particular robotics project, machine learning can be applied or not. Therefore, it will be also exciting to follow how the industry develops in terms of coping with the limitations, i.e. concerning the development of sensor technology or machine learning algorithm performance.

References

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