In fields like service robotics, medicine, entertainment and education, technical systems like robots and other machines are beginning to be part of the human environment. In order to make them flexible and suitable for use in complex environments it is necessary to give them a certain level of creativity. In this article, a technical concept of creativity is described with the overview of problems that occur when implementing these concepts in real technical systems. Trends and possibilities of creativity in robotics are given in the last section of the article.
Creativity however, is a very desirable attribute for technical systems which can bring a certain level of autonomy to the way they function and behave.

2. Creativity and artificial intelligence

Artificial Intelligence (AI) tries to model and create intelligent behaviour of machines by using computer software and programming as the platform. AI is mainly inspired by human cognitive abilities which are all together considered as general intelligence. General intelligence is an abstract term and very difficult to replicate, for that reason AI tackles certain separate problems which are considered as part of it. This mainly includes reasoning, knowledge, planning, speaking and learning which by them self are very complex cognitive abilities. Creativity on the other hand, is a feature of human intelligence which is represented in every of these cognitive abilities depending on the personal characteristics of the individual. Creativity involves motivation and emotion which are closely linked to cultural context and personality factors.

For AI, creativity is a highly desirable characteristic which can produce novel and unpredictable ideas. If the attributes and benefits of creativity want to be transferred to AI software it is crucial to know the mechanisms of its functioning. It is considered that there are three main types of creativity. The first one is combinational creativity which uses the combination of familiar ideas for the creation of new ones. This type of creativity is mostly implemented in AI systems because of its “simplicity” e.g. lower complexity then the other two types. The second is exploratory creativity where a certain concept or style of thinking is accepted from the culture or environment and then explored to its boundaries and tweaked for the purpose of creation of new concepts and ideas. The third is transformational creativity. This one happens when the accepted concept is altered in such a way that previous boundaries of the concept are removed or replaced by other concepts that enables creation of ideas which were previously impossible. The results of such a creative process can be so drastic that the results cannot be immediately validated and accepted. Combinational creativity can in this sense make no harm because it only uses familiar knowledge for the purpose of creating new ones. These new ideas can or may not make sense. Transformational creativity on the other hand would try to completely change the previous knowledge concepts and propose novelties. Accepting such concepts by the AI algorithm can lead the process of creativity in useless directions. For this reason, many researchers do not allow the AI algorithm to make changes to the core code and limit the process of searching or creating new ideas to a restricted space of solutions [1].

AI will have less difficulty in modelling the generation of new ideas than in automating their evaluation [1]. A big problem for AI is the evaluation of new ideas. Generating new ideas can be done very effectively with the use of modern algorithms which can produce a high number of ideas in a short period of time. These ideas unfortunately can often be useless and do not have any sense regarding the current context. There is currently no unique criteria for creativity that can be implemented in AI algorithms and real evaluation of ideas can currently be done only by humans.
3. Creativity in Robotics

Because of their physical dimension, robots provide a wider range of possibilities for acting on the environment than “software only” systems. They provide a physical extension to software and enable actions which can be evaluated in a human intuitive space. This makes them very interesting for the implementation of AI algorithms. Robots are now frequently used in unstructured environments where they have to be able to navigate without any previous input information, in verbal and physical contact with humans and other complex situations which display the need for their intelligent and flexible behaviour. New kinds of robots which are able to perform tasks that would request a certain amount of creativity if they were performed by humans are constantly being introduced to the market. They can dance, play an instrument, make up new jokes or communicate with people [2].

Previous generations of robots were automated by explicit hard coding of instructions which results in blind behaviour, following instruction after instruction. This kind of programming demands high creative thinking from the human during the programming work and leaves the robot completely depended on the human operator if any unpredicted situation occurs. Human creativity involves wide knowledge about the outer world, relations between objects and their physical properties [3]. The process of creative thinking uses all that knowledge and produces new outcomes. In order to enable robots to be creative, it is crucial to develop flexible knowledge bases which than can be modified by human or by the robots learning processes.

Fig. 1. iCub [4]

Besides the development of AI algorithms, a huge impact on this field has the development of sensors which enable the robot to sense its surrounding. Vision systems provide a great interface to the outer world which can be compared to the human sight. Haptic feedback can give the robot another interface to the environment through the sensing of forces that act upon it. Combining multiple sensory types, relative high level of awareness can be achieved by the robot and the potential learning abilities as well as the level of autonomy are growing.
In mobile robotics for example, algorithms such as SLAM (Simultaneous Localization and Mapping) in combination with different sensors have been used extensively during the last period for creating knowledge representations of the robot surrounding. Internet data bases for robots are becoming popular and efficient ways to share general knowledge models among robots. More efficient methods for exploiting this data for robot behaviour are constantly developed as well. Humanoid robots like iCub are very good platforms for research and implementation of various AI models and concepts.

It is not expected for researchers in the close future to be able to implement high level, human like creativity into robot behaviour. Creativity however, represents a certain “must have” feature because flexibility and the ability to come up with a solution to a given problem are crucial for functioning in complex environments.

4. Conclusion

The high complexity of creativity makes it hard to describe even on the philosophical level and todays technical systems with coded behaviour are not even close in achieving something that can be compared to human creativity. The reasons lie in the ability of the human mind to make bonds between knowledge, ideas and real life situations which can be inspired and driven by a variety of causes and internal motivation of the person. However, with the development of AI tools and robotics sensory devices, creativity on a lower level can be achieved, which can give such systems a dose of flexibility and a different dimension in comparison with hard coded machines.

Robots are the extension of software into the physical world and therefore represent the main carriers of future research that will bring artificial forms of creativity to the human society. With the raising level of autonomy and capabilities for making decisions, robots will eventually be able to make decisions which can be ethically doubtful. This will demand the implementation of certain judgment mechanisms which will assure execution of actions that are only beneficial for their environment.

REFERENCES