In this thesis it is investigated how behaviours can be taught to a robot, simply by demonstrating them. The robot thus has to observe the teacher and imitate its behaviour. These behaviours could be simple body movements, but also the stacking of blocks or even setting up a table. The teacher can be a human, but also another robot.

If we consider a humanoid robot, we can easily imagine that the robot is capable of making body movements, similar to those made by a human instructor. Suppose that such a robot sits in front of you while you lift your left arm. Is the robot now supposed to lift its left or its right arm? How can the robot know how to control its motors in order to lift its arm exactly the way the human instructor did? Suppose that the robot succeeds in lifting his arm, be it twice as high as its instructor did, can this be considered as a successful imitation? On the one hand, it is not since the robot did not exactly copy the demonstrated behaviour. On the other hand, the goal was to lift an arm and that is exactly what the robot did, so the imitation succeeded. But, how can the robot know that the goal was to lift an arm and that it is thus irrelevant which arm is lifted, nor that it matter how high it is lifted? Even the study of the imitation of simple body movements thus raises a set of interesting questions. The more complex the behaviours that must be imitated, the more difficult issues are raised.

In this work we do not adhere to the simple model in which a teacher transmits a repertoire of behaviours to a student, by demonstrating the different the different behaviours. Rather, a large set of robots (a population) is studied. In the population, each robot can learn behaviours from the others, avoiding the traditional fixed teacher-student perspective. This allows us to investigate how behaviours can emerge and spread in a population, but also how the behaviours can evolve.

We introduce a mechanism which allows the different individuals (agents) in the population to learn each others behaviours by imitating them. The exact nature of those behaviours is not specified in the framework. The framework itself is not new, it was previously used in a different context. In the text it is shown how the general framework can be used to learn simple body movements as well as more complex behaviour as the making of coffee. The general framework allows for the elegant answering of several important issues in the field of robot imitation.

The framework can be outlined as follows: all agents randomly move in a finite space. Whenever two agents meet, they start playing a game. During this interaction, one agent will act as a teacher, the other agent will act as a student. The teacher starts demonstrating a behaviour it already knows. The student observes how the teacher demonstrates the act and tries to imitate it. Important is now that the teacher investigates the imitative attempt and decides whether the game succeeds or fails. At that point, the teacher has to inform the student about the outcome of the game. Both agents will now adapt the set of behaviours they already know, using the knowledge they acquired during the game. For instance, the teacher can remove behaviours that no other agent can imitate form its memory, the student can notice that it observed a new behaviour and memorize it. The behaviour the student saw might resemble a behaviour already know and thus a small modification to that behaviour might be required. After modifying there behaviours, both agents stop interacting and start moving around again.

Whenever two agents meet, a new interaction starts. So, after a while, every agent has interacted many times with all other agents, both acting as teacher and as student. The outcome is that all agents in the population share the same behaviours, while this agreement is not centrally controlled. The repertoires of behaviours emerge and become shared as a result of self organisation.
The above outlined mechanism is described in detail in two separate case studies. Firstly, it is investigated how a population of agents learn a set of simple body movements using the framework. Several problems related to the imitation of body movement can then be studied. Secondly, the same framework is used to investigate how a population of agents can learn much more complex behaviour. As a case-study of intentional behaviour the ordering of objects in spatial configurations is studied. Typically for this intentional behaviour is that the exact sequences of actions performed by the student are irrelevant. Rather, the end configuration or the goal are important.

These interactions (imitation games) cause the emergence of a shared repertoire of behaviours in a population of agents. This means that the behaviours of all agents resemble each other that much that they can be imitated by all agents. If the behaviours learnt by the agents are simple actions, than all agents will learn those actions or very similar ones. Also when the agents imitate intentional behaviour, the intentions will spread over the entire population.

This research proves that the framework of imitation games is very flexible: both the imitation of vowels, actions, sequences of actions and intentional behaviour can be investigated in the same paradigm. Flexibility is also illustrated in other domains. Among others it is shown that the parameters occurring in the paradigm do not have crucial values: the same behaviour occurs for a wide range of parameter values.