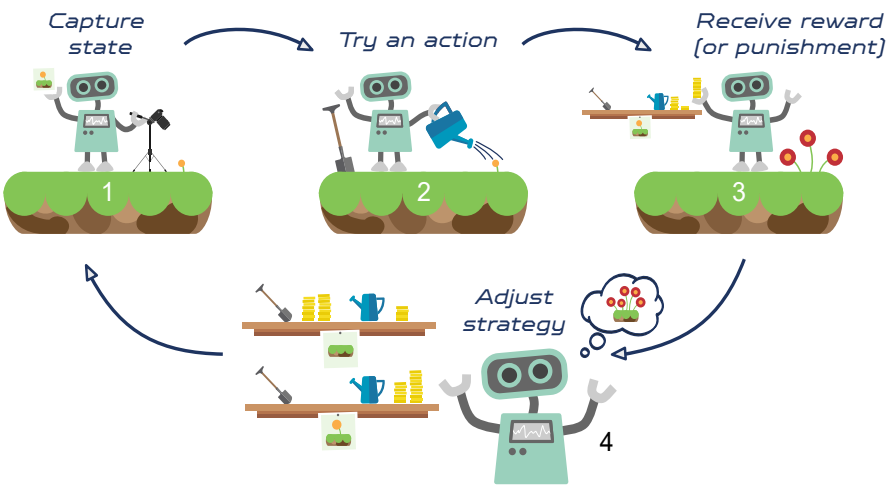
# DOT, DOT, COMMA, DASH...

**It‘s nice to see what the robot arm does: drawing squares, triangles and finally houses. But - what good is a robot like this? It‘s not great art, nor is a robot that can draw small icons really helpful or useful in real life.**

In order to learn how to draw certain things, the robotic arm uses a technique known as Reinforcement Learning. In reinforcement learning, the AI system first records the current state, e.g. by reading out sensor data or analyzing the current state of a program. The AI system then performs an action that is possible in this state. Initially, it will select these at random, but later the actions that bring the AI system closer to its goal (e.g. drawing a house) will be used in particular.

**How can you tell the AI system which actions are good for achieving the goal and which are not?** Quite simply: the AI system is rewarded if the action is correct. You can also say that you reinforce the behavior of the system, which is why it is called reinforcement learning. A reward increases the probability that the AI system will select this action. If it is wrong, the AI system is ‘penalized’. If this happens, the probability that the AI system will select the action it has just performed again in this state is reduced. In this illustration you can see again how the process works. The robot is supposed to learn how to take care of plants.



# 05 PAINTING CLASS

Let's assume our robot arm is supposed to draw a heart. The result:

By pressing the „success“ button, we show the AI system that the drawing was good, thus, we reward the system.

If, on the other hand, the AI system draws this picture:

we should select the „fail“ button to tell the AI system that the picture was not suitable or of good quality. We penalize the AI system.

**Does this learning process sound familiar to you?That's right!** We train pets in a similar way and we humans sometimes learn in the same way, too. The term reinforcement learning comes from psychology and describes learning through reward or punishment. For example, if you want your puppy to stop at the side of the road before you cross it, you train it to do so. You demonstrate the desired behavior and reward it (e.g. with a treat) when it stops at the side of the road. If, on the other hand, it simply runs across the road, the puppy does not get a treat. It is important that it understands the connection between its action and the reward or punishment. SImagine being scolded and not knowing why. Then you would not be able to improve your behavior or you might even change a behavior that was not meant at all!

This is also important with the reinforcement learning of AI systems, but it is not quite so simple. The reward is represented by a complex mathematical formula that has to be adapted and changed. And we all know from math lessons that this is not that easy! ! It also takes quite a long time for AI systems to learn a good response. The AI system has to be confronted with very similar situations very often and also go through many different situations. This takes some time!

# 05 PAINTING CLASS

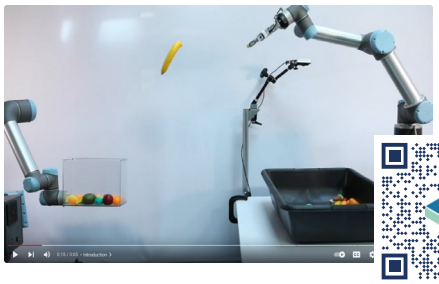
One area of application for reinforcement learning is robotics. The tasks performed by robots are often very complex. Programming them with classic algorithms is time-consuming and expensive. Instead, reinforcement learning is used. The robot learns through trial and error and is rewarded or penalized accordingly.

**Have you ever wondered how self-driving vehicles learn to react in certain situations?** Reinforcement learning is also used here. If the AI system in the autonomous vehicle assesses a situation correctly, the human driver does not intervene. However, if it assesses the situation incorrectly, the human takes control. This allows the AI system in the vehicle to recognize that the assessment was incorrect and subsequent actions are adjusted.

Another application is the training of AI systems to play games. Just like computer players, they receive points for successful moves and lose some for mistakes. In this way, the AI systems learn successful game strategies and can successfully master games without any human guidance. For example, AI systems can play Super Mario, but can also defeat human opponents in chess or Go!

*An AI system plays Super Mario. But it only works really well for one level..*


*This robot learns to walk thanks to reinforcement learning.*



*A robot that can toss? That's also possible with reinforcement learning.*

# SOURCES

Graphic „Reinforcement Learning“
CC BY Stefan Seegerer, Tilman Michaeli, Sven Jatzlau; colors modified

Video „MarI/O - Machine Learning for Video Games“
https://www.youtube.com/watch?v=qv6UVOQ0F44

Video „Robots Learning to Toss“
https://www.youtube.com/watch?v=-O-E1nFm6-A

Video „Learning to Walk via Deep Reinforcement Learning“
https://www.youtube.com/watch?v=n2gE7n11h1Y