**Hardware**

The turtlebots must transport carriages from one point in a warehouse/factory to another point. In addition to this it was decided that the turtlebots had to be able to transfer carriages from one bot to another. A morphological chart was used to create multiple solutions for this task. The solutions that were most promising and realistic were worked out with more detail. Initially the turtlebots were meant to have multiple specializations. These specializations were also in the morphological chart. Two of these specializations were chosen, but in the end, it was financially and time-wise not feasible to implement both specializations. Hence only one concept was realized.

**Stack up**

The position of the camera was moved to the front of the turtlebot, beneath the disk on top of which the laptop is placed. The system that hold the carriages and is capable of transferring the carriages is mounted on top of the disk above the laptop.

Six grippers are mounted on the turtlebot, each can carry a single carriage. To align the carriages for transfer the grippers can revolve around the turtlebot. For this purpose, the grippers and a stepper motor are mounted on top of a Lazy Suzan bearing. A pinion on the motor and a gear make it possible for the bearing to revolve. A reed contact and a magnet are used to keep track of the position of the grippers instead of an encoder. A slip ring is used to keep the electrical cables from getting entangled or breaking lose because of the movement. This design is displayed in figure 1.

**Gripper**

When a carriage is pushed into the gripper a plate with an axis attached to it will be pushed back. Pushing the plate back will cause the fingers to grip the carriage. The gripper will be mechanically locked by the axis, to be released by a servo. When released a spring pushes the plate back, causing the gripper to open. The carriages will be pushed into the carriage by driving the turtlebot against it. To get the alignment right the gripper is revolved around the turtlebot first.

The carriages are a standard size of 50\*50\*100mm and are intended to carry small parts such as bolts. A photograph of the gripper is shown in figure 2.