Ceilbot vision and mapping system

- Provide depth and camera data from the robot's environment
- Keep a map of the environment based on the received data
- Keep track of the robot's location on the map
- Recognize and locate pre-defined objects that might be found in the operating environment

- Evaluate what hardware and software is required to achieve the decided tasks
- Select the hardware to be used
- Design and construct a rig to mount the hardware on
- Write and implement the software

Hardware options

- Possible methods for 3d data aquisition:
  - Time-of-flight depth camera
  - Time-of-flight scanner
  - Structured light scanner
  - Stereoscopic vision using two cameras
- Webcam used for image aquisition
- Mounting gimbal self built out of aluminium and plastic
  - Must be able to turn about the vertical axis and tilt up/down
  - Actuated with servos and/or stepped motors
- Servos or motors strong and accurate enough to reliably steer the gimbal
  - Positioning must be repeatable and accurate even with small movements
  - Scan matching for mapping benefits from accurate gimbal steering

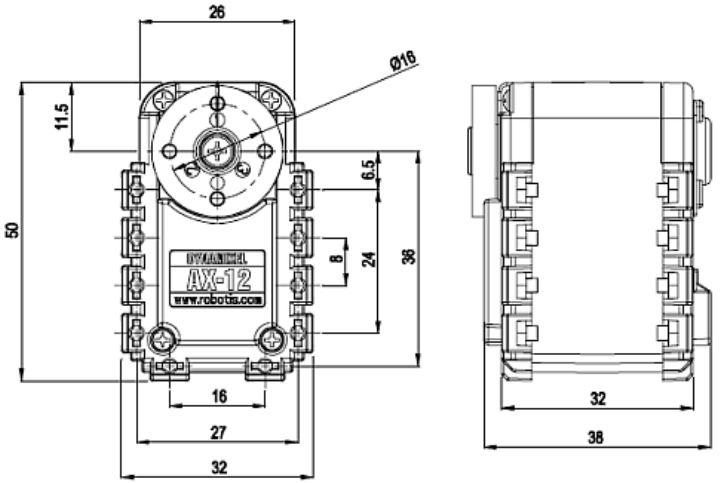
Chosen hardware

●3d depth cameras were deemed too expensive at the time of planning. A time-of-flight line scanner was already available at the lab.

●A combination of stereoscopic vision and a time-of-flight line scanner was chosen for 3d data aquisition. Stereo vision would possibly be assisted by a line pattern laser pointer.

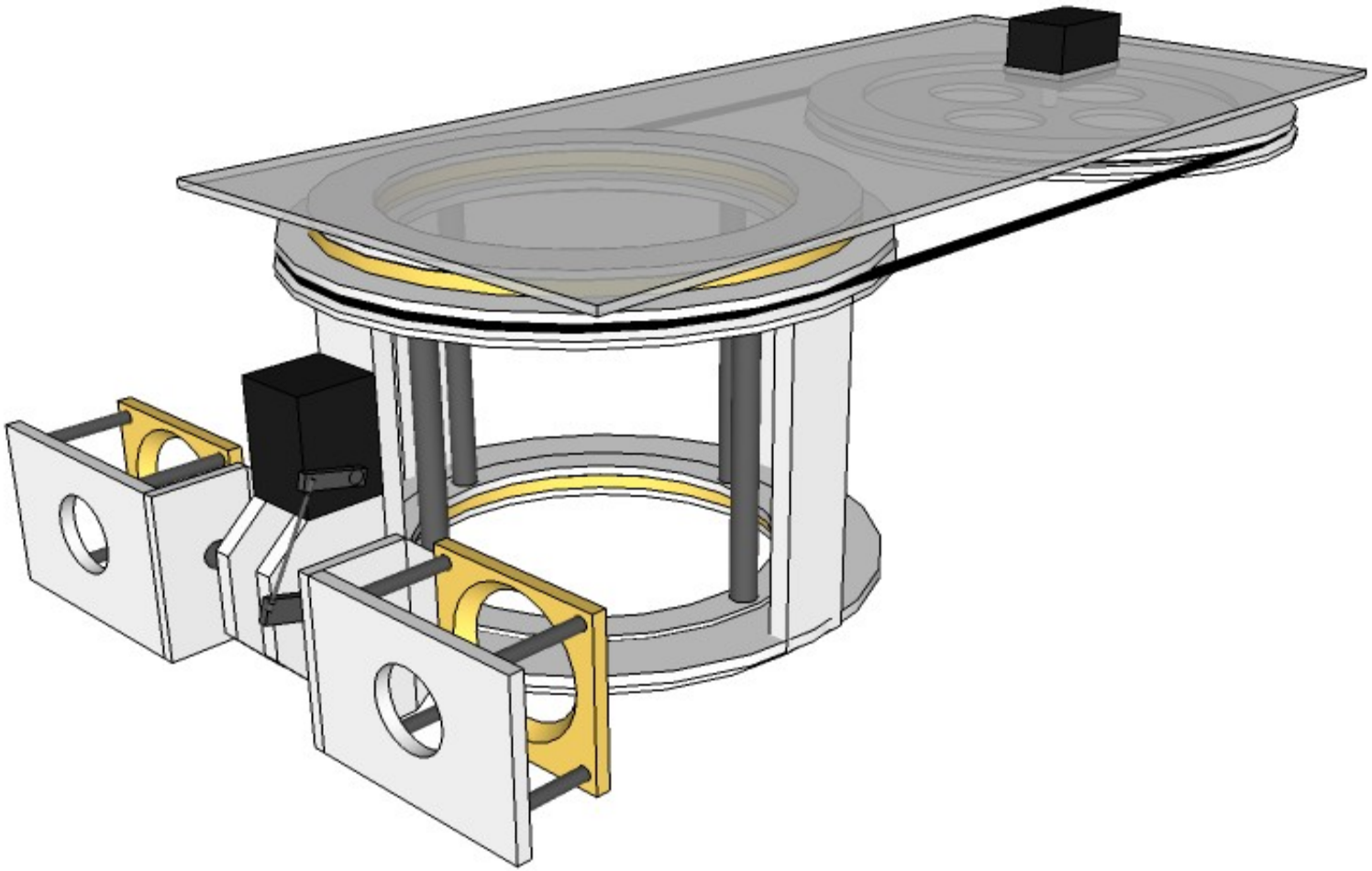
●Two Logitech Webcam C600 cameras were chosen for the vision.

●Two Robotis Dynamixel AX-12 servos were chosen for the gimbal actuators. These servos are controlled with a serial data adapter through the USB port. They are quite strong and accurate and not too expensive.

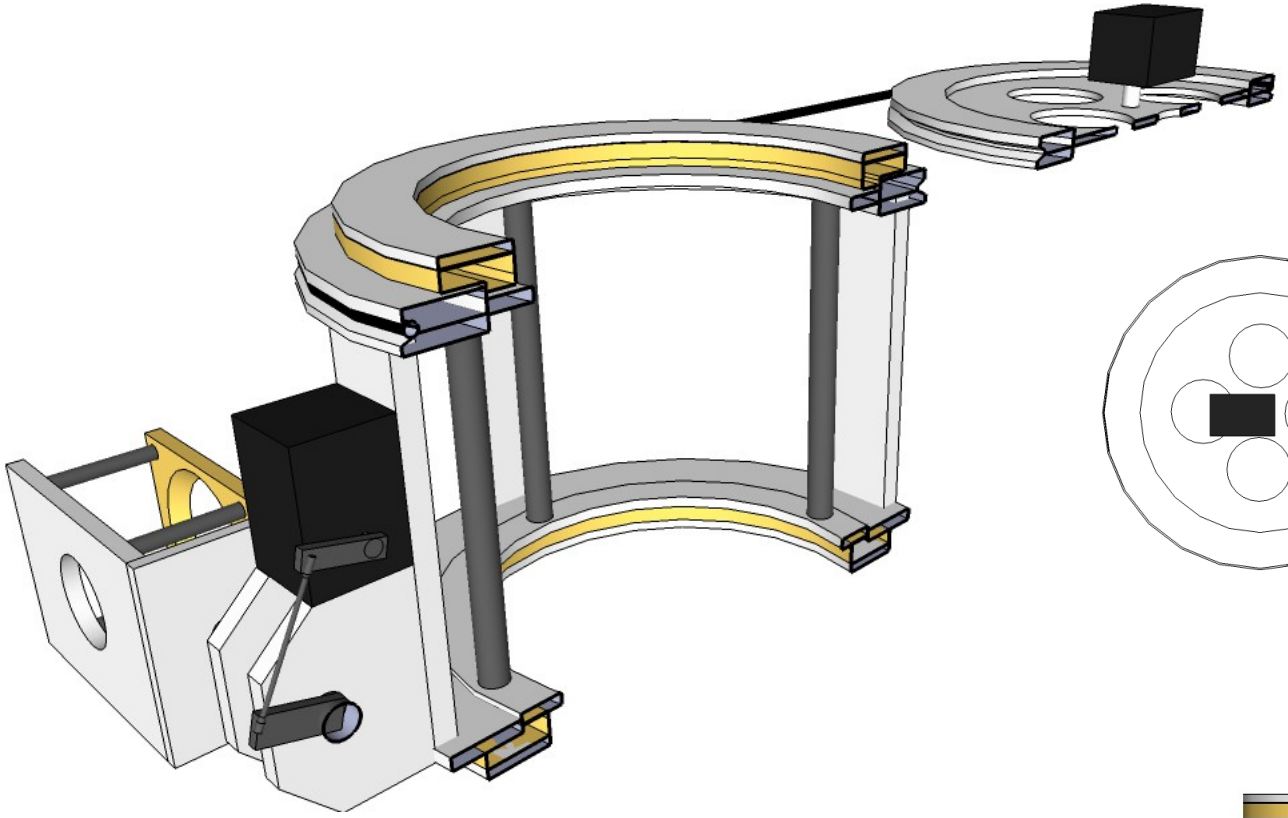


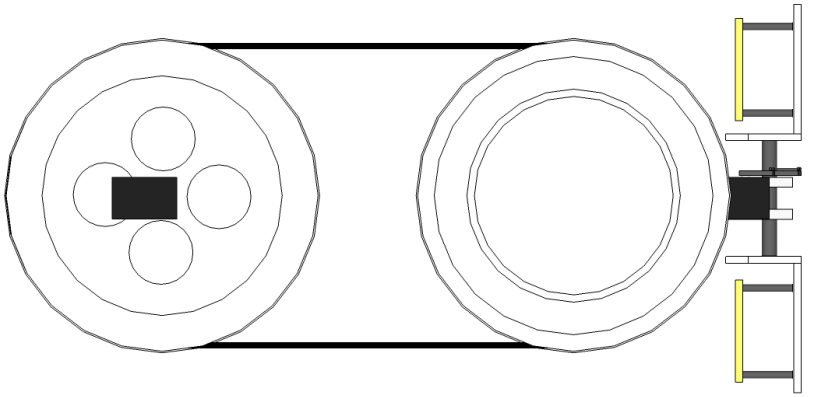
Mounting gimbal design

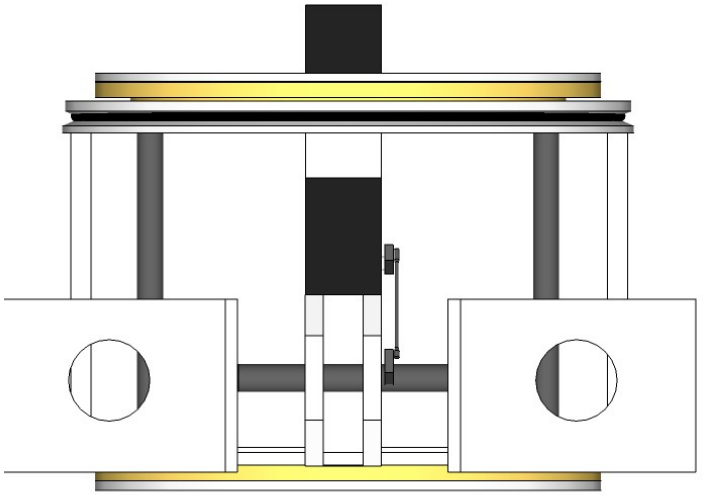
- 2 DOF steering (pitch and yaw)
- Vision must not be occluded by the manipulator arm, so the arm will be mounted through the middle of the gimbal.
- Servo angle range is 300 degrees, large primary drivewheel required for proportional control. The servo also has an option for continuous turn.



Mounting gimbal design



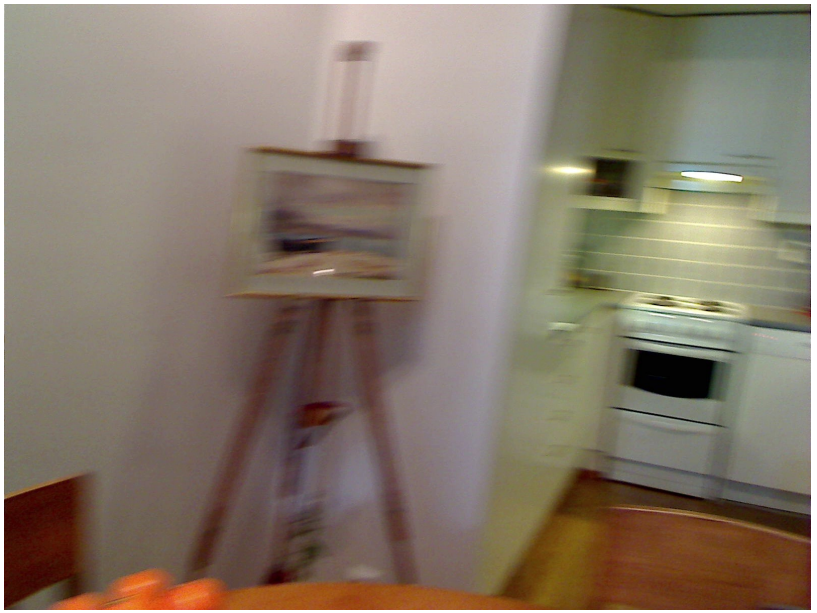




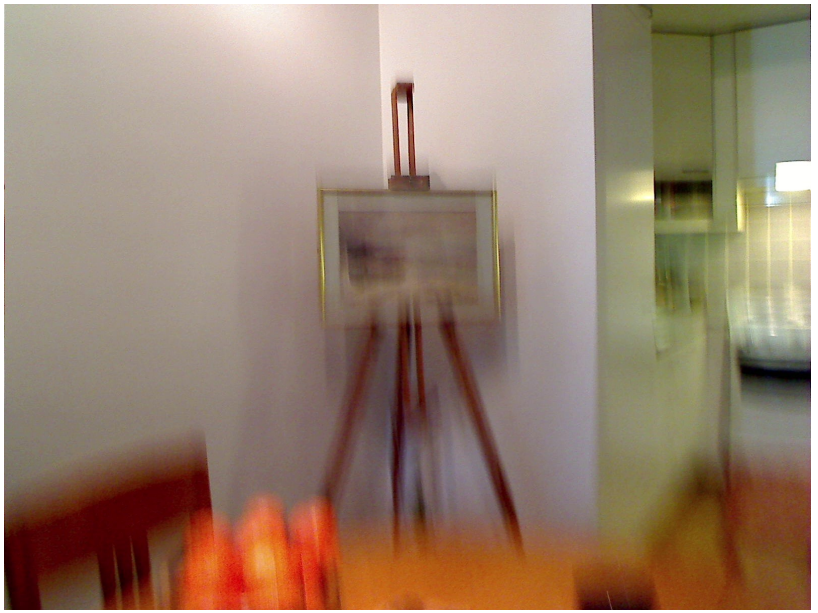
Problems with webcams

- The chosen webcams suffer of the ”rolling shutter” effect. Image pixels are retrieved one by one starting from the upper left corner of the image from left to right, top to bottom. It takes a significant time to scan a whole picture, so there is time for the scene to change when an image is drawn. This results in warped pictures whenever the camera is moved.

- This motion warping limits the usefulness of the computer vision since the robot must stop every time it needs to view its surroundings. Also tracking moving objects stereoscopically becomes impossible.



Sideways motion (left to right)



Downward motion

The scene gets squashed and warped according to the direction of camera movement

Microsoft Kinect as a 3d camera

- Microsoft released its Kinect game controller at the beginning of November 2010. The Kinect is essentially a 3d range camera capable of producing real-time depth data.

- Very quickly after the Kinect's release an open source library for exploiting the 3d camera capabilities was published. The library is made by independent developers, apparently without Microsoft's consent, by reverse-engineering the output signals of the controller.

- The kinect would be the perfect sensor for the Ceilbot mapping and vision system, since it combines a very accurate 3d camera with a normal visual camera.

- It is most likely that the mapping and vision system design will be adapted to use the Kinect instead of the stereo cameras and line scanner.