gaze tracking for robotic control in *intelligent* teleoperation and prosthetics

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motivation

- consider a prosthetic hand:
  - mechatronics can be amazing, but
  - no *control* by the user:
- *either* use **non-invasive interfaces** (e.g., emg, voice commands, etc.) with lack of *feeling*
- *...or* use **invasive interfaces** (i.e., directly connect nerves to robotic artifacts), but s.o.a. still behind
- movie (reproduced from cyberhand.org)

adding *intelligence*

- need the prosthesis to *autonomously* grasp the right way
- feed it with *sensory data* (also coming from cameras)
- use *machine learning methods* to adapt to the user's needs and habits

gaze tracking

- ...is a further way of training the system:
- humans fixate what they are trying to grasp rather than their own limbs (e.g., [Johansson *et al.*, 2001])
- try and grasp what the user is fixating

teleoperation/1

- bears more than a casual resemblance with prosthetics
- poses some additional problems (e.g., robot kinematics and reaching)
- gaze is used so far to activate a saccade toward the required point in camera space

teleoperation/2

- the user looks at a monitor connected to the robot's camera; the user's gaze is monitored over 400msec
- if the variance of the gaze signal stays low over the whole time window, the system guesses the user is fixating a point in the robot's workspace
- a saccade is commanded and the fixated point is brought to the fovea

(movie)

directions: machine learning

- essentially a classification algorithm, e.g., try to discriminate images with a face in it
- use them for
  - **object classification** is that thing in front of me a pen, a hammer, a ball or a bottle?
  - **inverse models** you want me to reach the pen, how should I move my joints?
  - associating **objects and affordances** you used a power grip on the hammer; that looks like a hammer; let me do the same

directions: reciprocal adaptation

- associating objects, their positions and the ways of grasping them
- guessing the user's will to grasp via gaze tracking
- *training phase* (performed by the user): the system adapts to the user
- *testing phase:* the user adapts to the system and becomes more and more proficient