Project 4: 3D tracking of facial features

Motivation: Patients undergoing surgery and/or radiotherapy in the oral region, especially the tongue, have the risk of limited tongue mobility with serious deterioration of oral functions, such as speech, food transport, swallowing, and mastication. The mobility of the tongue is expressed in the so-called 'Range of Motion'. To study the statistical correlation between the range of motion and a given treatment, this range of motion should be measured in a population of patients. This is to be done before and after the treatment.

Statement of the problem: To measure the range of motion, patients are asked to move their tongue to standardized, extreme positions, left, right, forward, downward and upward. A triple camera system is used to measure the 3D positions of the tongue tip. Of course, to compare these positions, pre- and post-treatment, the positions should be expressed with reference to a fixed, well-defined coordinate system that is attached to the head. How to derive these measurements from the recorded triple videos?

Assignment: Develop and test a method that is able to track the tip of the tongue and some facial landmarks so as to find the 3D positions of these points. Using these facial landmarks, define a 3D reference coordinate system that is attached to the face. Express the 3D position of the tongue tip in that coordinate system. Evaluate the method.

Tips:

- Images of checkerboard (size of the squares is 10x10 mm^2) are available to calibrate the cameras.
- Easy to interpret facial features, such as the nasal point, the sub-nasale (lowest point of the nose in the midsagittal plane), and the corners of the eyes, etc. are preferred.
- To initiate the system, it is allowed to manually pinpoint these points, including the tip of the tongue, in the first frame (e.g., Matlab function `getpts`).
- Maybe it is possible to enrich the description of some of these points by locally reconstructing the 3D surface surrounding these points. The computer vision library of Matlab contains several functions for this 3D reconstruction. See the syllabi.
- If at a certain frame, the method fails to track one or more points accurately, then automatic detection of this situation, so that the tracking can be stopped and after manually correction be continued, is not as serious as that the tracking just continues with erroneous results.
- Since we have three cameras, the system is partly redundant. This can be used to make the system more robust, but also to assess the system.

Grading (see table in grading section): the grade depends on the quality (robustness, accuracy, etc.) of the solution, the thoroughness of the evaluation, and the quality of the report.