3D Tracking of Facial Features

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***Abstract*—In this paper, a 3D facial features tracking system is developed to track facial features and measure the mobility of the tongue tip. The system uses Kanade-Lucas-Tomasi tracking algorithm to track a set of points of interest, and it uses Random Sample Consensus algorithm to eliminate the outliers and estimate parameters. Then these parameters are used to measure the tracked points in 3D space.**

***Keywords*—Point tracking, RANSAC, Stereovision**

I. Introduction

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.

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. The developed system is able to track the motion of facial features and the tongue tip and then measure the 3D positions of tongue tip to establish a Range of Motion for the tongue tip.

A brief introduction to the topic is presented first, then the methodology which involves the three main topics (2D tracking, 3D tracking, and 3D measurements) is presented, then the results of the experiments will be presented and discussed.

The introduction contains (1) a background, (2) the definition of the problem that is addressed possibly with a research question and subquestions, (3) a short outline of the report.

II. Methods and Materials

A. Materials

A short inventory of what has been used.

B. Methods

1) Analysis: Start with defining the overview of the problem in a more mathematical context. What is the input? What is the desired output? (Introduce mathematical symbols for the input and output variables). What is in rough steps the strategy to get the output from the input?

Next, define the subtasks in more detail. For each subtask, introduce variables whenever needed, and set-up the mathematical relations (equations) between these variables, possibly combined with pseudo code. Do **no**t use Matlab code. Describe your algorithm such that the principle of operation becomes clear. For that, use mathematical style pseudo code. See: https://en.wikipedia.org/wiki/Pseudocode and pseudo-code examples provided in https://en.wikipedia.org/wiki/Category:Articles_with_example_pseudocode. The only place in the report that contains Matlab code is the appendix (you should add your listing as an annex).

2) Performance evaluation: For a performance evaluation, you often need to set-up an experiment. Describe the (protocol of the) experiment. Describe how the outcome of the experiment will be processed. Often, you need reference values, i.e. a gold standard, or a ground truth. Describe how this is achieved. If the processing is done statistically, mention the statistical test or statistical inference method.

III. Results

Here, you give the results of what is described in Section II: tables, images and/or graphs. The accompanying text of these tables, images and/or graphs clarifies how they are related to the methods described in Section II.

If you have any remarkable observations, mention and describe them here, but without an interpretation, explanation, or meaning. Do not introduce new methods in this section. And do not give an interpretation or a judgement of these results.

IV. Discussion

Give an interpretation and judgement of the results. If you had any remarkable observations, discuss them here to give them meaning (interpretation, explanation, implication).

Describe limitations of the study. If applicable, compare your results with results from literature. If applicable, provide recommendations for further work.

V. Conclusion

A conclusion reviews the main points of the paper. Describe the overall implication of the results to the original problem statement (or research questions). Do not replicate the abstract as the conclusion. A conclusion might also elaborate on the importance of the work, or suggest applications.

TABLE I: An Example of a Table

One	Two
Three	Four

APPENDIX A
GUIDELINES FOR FORMATTING MATH

If you are using Word, use either the Microsoft Equation Editor or the MathType add-on (http://www.mathtype.com) for equations in your paper.

Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1). Punctuate equations when they are part of a sentence, as in

$$f_n = \sum_{m=0}^{N-1} F_m exp(2\pi \mathbf{j} \frac{nm}{N}). \quad (1)$$

Be sure that the symbols in your equation have been defined before the equation appears or immediately following. Italicize symbols (T might refer to temperature, but T is the unit tesla). Refer to (1), not eq. (1) or equation (1), except at the beginning of a sentence: Equation (1) is ... .

APPENDIX B
GUIDELINES FOR GRAPHS AND TABLES

A. Graphs and Images

Below each figure (graph or image) there must be a caption with a figure number and a figure title. See Fig 1. Figure titles should be legible, approximately 8 to 10 point type. Each figure should be referenced in the text. Each axis of a graph should have a label. Use words rather than symbols. As an example, write the quantity Wavelength, or Wavelength λ, not just λ. Put units in parentheses. Do not label axes only with units. As in Fig. 1, for example, write Wavelength (nm), not just (nm).

B. Tables

Tables should have a table caption on top. See Table I. Tables should be numbered with Roman Numerals (I, II, III, IV, and so on). Tables should also always be referenced in the text.

C. Videos

Videos should be uploaded as separate files. The preferred video format is mp4. Dont make the video files unnecessarily large. 20 Mbytes is acceptable, but 200 Mbyte is not. Appendix A contains a Matlab script that you can use to resize the frame size of a video. The parameter *quality* controls the amount of compression. Sometimes it is also useful to skip frames. For instance, only write the odd frames to the output video.

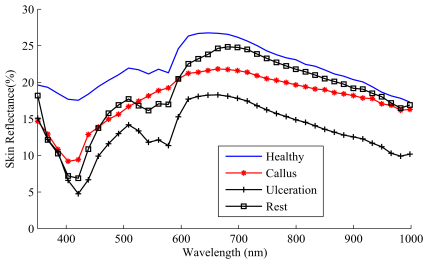

Fig. 1: Examples of spectrum from different classes

APPENDIX C
MATLAB SCRIPT FOR RESIZING A VIDEO

```
%% convert a video
clear variables
close all

inputname = 'input\_name.mp4';
outputname = 'output\_name.mp4';
profile = 'MPEG-4';
framerate = 25;
quality = 75;

resize = 1;     % resizing needed?
width = 640;    % if so, this the new width
height = 480;   % and this is the new height
crop = 0;       % cropping needed?
croprect = [ 142        36       563       672];

obj = VideoReader(inputname);
nFrames = obj.NumberOfFrames;
wobj = VideoWriter(outputname,profile);
wobj.FrameRate = framerate;
wobj.Quality = quality;
open(wobj);

% Read and write one frame at a time.
hwait = waitbar(0);
k = 1;
while hasFrame(obj)
    im = readframe(obj);
    if crop                          \% crop if wanted
        im = imcrop(im,croprect);
    end
    if resize                        \% resize if wanted
        im = imresize(im,[height width]);
    end
    writeVideo(wobj,im);
    if~mod(k,10)==1,waitbar(k/nFrames,hwait);end
    k = k+1;
end
delete(hwait);
close(wobj)
```

APPENDIX D
GUIDELINE FOR REFERENCES

In text, refer simply to the reference number. Do not use Ref. or reference except at the beginning of a sentence: Reference [3] shows ... .

REFERENCES

[1] H. Kopka and P. W. Daly, *A Guide to LaTeX*, 3rd ed. Harlow, England: Addison-Wesley, 1999.