Smartphone-based Urine Strip Analysis

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Background and Aims

A common practice among people with diabetes is monitoring their glucose and ketone levels. This is possible to do either at home, or at medical centers equipped with the necessary urine strip reader. The nature of this procedure, demands that the user either compares the resulting colours with a set of predefined colour levels provided by the strip manufacturer or visits a medical facility,.

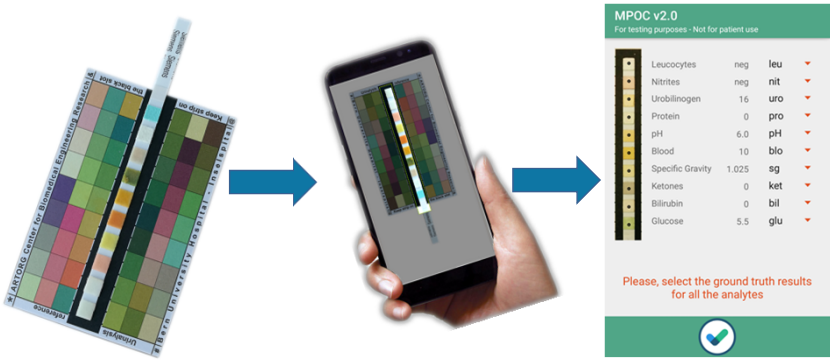
The aim of this project is to overcome the inconvenient and error-prone procedure that each individual has to go through. The application needs only an image of the urine strip and produces an automatic and accurate estimation of the indexes.

Method

The mobile point-of-care (mPOC) application uses **Image Processing** techniques and **Machine Learning** algorithms, in order to detect the strip in the provided image and estimate the levels of the indexes.

1. The user places the strip on the application's detection card and takes a picture. The system calculates certain key points within the image and matches them to the detection card's initial design. With the help of this matching, the detected card is obtained and transformed into an upright position.
2. The pads for the different indexes are located within the detected card. Every pad's colour is then assigned an estimation for the corresponding index.
3. The index's level estimation is achieved by comparing the corresponding pad's colour-vector to the colour-vectors provided by the manufacturer and finding its closest match.

The App attempts to meet challenges related to colour variability of the captured images, by applying colour correction in the form of **Support Vector Regression** (**SVR**).



Technical Evaluation

The technical evaluation resulted to the following: **Accuracy$_{Ketones}$ =63%** and **Accuracy$_{Glucose}$ =81.5%**.
The confusion matrices are given in **Table 1**.
From **Table 1** it is shown that the estimated values are as close, if not exact, to the actual values and in fact the system exceeds the actual values by more than 1 level, on rare occasions.
By considering estimations lying within the range of +/- 1 level of the ground truth level, the two analytes result in: **Accuracy$_{Ketones}$ =92.6%** and **Accuracy$_{Glucose}$ =98.1%**

A dataset consisting of strip images taken under **3 different lighting conditions** and by **3 different Android smartphones** was created. For both Ketones and Glucose all different intensity levels are included. Thus, a total of 108 images were used.

Table 1.a: KETONES

GROUND TRUTH \ PREDICTED	0	0.5	1.5	4	8	16
0	7	2	0	0	0	0
0.5	2	7	0	0	0	0
1.5	2	7	0	0	0	0
4	0	2	0	7	0	0
8	0	0	0	4	4	1
16	0	0	0	0	0	9

Table 1.b: GLUCOSE

GROUND TRUTH \ PREDICTED	0	5.5	14	28	55	111
0	9	0	0	0	0	0
5.5	0	9	0	0	0	0
14	0	0	9	0	0	0
28	0	0	0	9	0	0
55	0	0	0	0	2	7
111	0	0	0	1	2	6

Conclusions

The system has proven to produce valid and fast results (**3-10 sec.**).
For future improvements each analyte will be individually parameterized and optimized, according to its own colour palette. Additionally clinical testing shall be conducted using data ranging over all possible estimations.

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