Patient Friendly Kidney Function Screening

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Chronic Kidney Disease

CKD was ranked the 13th leading cause of death in 2013.

The major problem associated with the disease is the awareness.

The Solution is Early Detection.

Creatinine is a chemical waste generated from muscle metabolism.

Creatinine level in blood is an indicator for kidney performance.

Glomerular Filtration Rate

\[ \text{GFR} = 175 \times \left( \frac{[S_{\text{cr}} \times 0.0113]^{-1.154}}{(\text{age})^{-0.203} \times (0.742 \text{ if female}) \times (1.212 \text{ if African-American})} \right) \]

Objective: Kidney Function Monitoring

1. Provide a diagnostic method Deliverable to end-user.
3. An Affordable way for early detection of kidney failure disease.

<table>
<thead>
<tr>
<th>Current Creatinine detection test cost</th>
<th>Proposed method cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>35-60 $ US dollar</td>
<td>0.3 – 1 $ US dollar</td>
</tr>
</tbody>
</table>

4. Imagine... Saving lives by early detecting kidney failure.

Merging the idea of urine test strip and Immunoassay. Detection method is strip’s Colorimetry changes with Jaffe’s reaction.

Integrating Machine Learning techniques to measure colorimetry changes.

Using a Smartphone camera for detecting colorimetry changes by capturing the strip image.

Materials and Methods

- Lateral flow biosensor designed using Blood Separator pad.
- Operating principle is chemical biosensor based on Jaffe’s Reaction.
- Images captured inside light box.
- We computed the levels of creatinine (Scr) that lead to different eGFR values, using the MDRD equation.
- Four categories (Other male, Other female, African American male, and African American female) for age between 1 and 120 years of age.

Results

- Total 65 different creatinine conc. tested.
- Total 2340 images were conducted.
- Test strip detected and localized by using YOLO Deep Learning regression model.
- Features are extracted using an Overlapping sliding window that scans the detection area of the test strips.
- Feature extraction techniques applied are:
  - Raw RGB pixels
  - Histogram of Gradients
  - Histogram of Colors
- Features extracted were used to train machine learning models:
  - Linear regression
  - Logistic regression
  - Nearest neighbor regression
  - Support vector regression

<table>
<thead>
<tr>
<th>Feature</th>
<th>Linear Regression</th>
<th>Logistic Regression</th>
<th>Nearest Neighbor Reg.</th>
<th>Support Vector Machine</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGB pixels</td>
<td>0.51</td>
<td>0.81</td>
<td>0.39</td>
<td>0.44</td>
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<tr>
<td>Histogram of Gradients</td>
<td>0.77</td>
<td>0.92</td>
<td>0.75</td>
<td>0.79</td>
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<tr>
<td>Histogram of colors</td>
<td>0.27</td>
<td>0.38</td>
<td>0.23</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Conclusion

Developing an easy method to detect kidney disease is possible by using lateral flow paper microfluidics. Integrating smartphones in healthcare applications introduces an easy way to detect and monitor various diseases.

Acknowledgment

Thanks to Micelle O’Shaughnessy, Clinical Assistant Professor Medicine-Nephrology at Stanford School of Medicine, and Darlene Drechsler-Fernandez, Nephrology Nurse Practitioner Kaiser at Permanente San Francisco Medical Center for helping to visualize patient needs.

Future Work

Plan is to extend the biosensor ability to detect potassium levels from blood drop and creatinine/albumin and protein level from urine as well to evaluate kidney disease prediction.

References