**Self-care Management: Patient-Centered Diabetic Wound Care Using Smart Phones**

**Motivation**
- Diabetes affects over 8 percent of the U.S. population and the overall diabetes health care costs were estimated at $174 billion in 2007, which are expected to double by 2034.
- Chronic wounds, such as diabetic foot ulcers, affect 5-6 million people in the U.S. and the relative treatment cost is estimated at $15,000 per year per case.
- Diabetes self-care management is complex, involving regular monitoring of glucose, weight, physical activity and diet.
- For patients with diabetic foot wounds, regular monitoring and care can accelerate wound healing and reduce the need for amputation.
- Timely feedback can improve patient’s awareness of their health and diabetes and reduce the risk of complications.

**Project Goal**
- Research and develop a smartphone-based application for use by patients with type 2 diabetes.
- Design and implement a smartphone app with intelligent feedback to help patients better manage their diabetes by using user study input.
- Enable tracking of chronic wound healing progress quantitatively on a smartphone.
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**Usability Study in Lab**
- We conducted the usability study in the UXDM Lab at WPI with 5 subjects (4 females, 1 male) and used an eye tracker to record the users’ gaze to better understand how they were reacting to our app.
- Key usability study findings are:
  1. When user finishes a task of adding activity record from the favorite list, app should return to the main screen of the “Activity” section, rather than the favorite list.
  2. Users have difficulty in inputting numbers using textboxes. To solve this problem, we implemented “Number Picker” for easier input control.
  3. When viewing data with charts, target goal should be shown to assess progress.
  4. Goal setting should be a doctor-only function. Subjects were not sure about their goals in terms of exact values. They did not even know what glucose level is dangerous to them.
  5. “Favorite Physical Activity” list should be pre-configured by either patients’ caregivers or us (adding defaults with common sense)
  6. Some new featured are requested by the users such as diet tracking (e.g. carbs), automatic activity tracking and sync with other services (e.g. MyFitnessPal).
- The main drawbacks for the mean shift based wound boundary determination method are:
  1. Whether the patient has an amputated toe or not will influence the wound boundary determination.
  2. No visual features with clinical meanings of the foot ulcers has been extracted and exploited as the determination basis.
  3. This method still lacks the capability of self-adaptation based on clinical inputs.
  4. The boundary determination accuracy is not constant since the performance still depends on the region fusion parameter setting.
  5. To overcome these limitations of the mean shift based method, we implemented machine learning based algorithms for the wound determination task.
- Three experienced wound clinicians from UMass Medical School labeled the 42 collected wound images independently. Afterwards, we combined the three labeling results by performing a simple voting operation on each image pixel and the results serves as the ground truth for the supervised machine learning algorithm.
- We applied a modified machine learning based solution (the original version has already been successfully used for human being recognition area). The core idea of this approach is to:
  1. Use the dense sift feature vector to describe each super-pixel.
  2. Train and apply the SVM based binary classifier to find the wound super-pixels.
  3. Use the conditional random field (CRF) model to refine the determined boundary.
- We evaluated our method on 42 sample images using leave-one-out cross validation method. The resulted Matthews Correlation Coefficient (MCC, which is ranged from -1 (worst) to 1 (best)) is 0.7, which is obviously better than 0.51 provided by the mean shift based method.

**Application Architecture**

**Application User Interface**

**Feedback and Report**

The feedback engine is core to addressing one of the research challenges of this project, namely to design an app that motivates and engages patients in taking better care of their health, specifically those health activities that will keep their diabetes and diabetic foot ulcers under control. The feedback to users is provided in four ways:

1. When users enter data values for their glucose, weight, physical activities, etc.
2. For glucose, weight, and physical activity, the initial screen shows a trend line of historical values with dotted lines representing the user’s selected goal.
3. Based on user feedback, we added a data analyzer function that can be selected from the main glucose, weight, or activity screens.

**Machine Learning Based Wound Boundary Determination**

**Wound Boundary Determination Method Flowchart**

**Wound Area Determination Results**

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