AI for Lifestyle self-management, Validation and Empowerment (ALiVE)

Ming Zhaoyan 明朝燕
1 Nov 2018
• 3H Problem 三高症
  • Hyperglycemia (diabetes) 糖尿病
  • Hypertension (high blood pressure) 高血压
  • Hyperlipidemia (high cholesterol) 高血脂

• ALiVE architecture of AI innovation and system
• Clinical studied, trials, and deployment
Global 3H Problem

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of Diabetes People</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>98.4 million</td>
</tr>
<tr>
<td>India</td>
<td>65.1</td>
</tr>
<tr>
<td>U.S.</td>
<td>24.4</td>
</tr>
<tr>
<td>Brazil</td>
<td>11.9</td>
</tr>
<tr>
<td>Russia</td>
<td>10.9</td>
</tr>
<tr>
<td>Mexico</td>
<td>8.7</td>
</tr>
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<td>Indonesia</td>
<td>8.5</td>
</tr>
<tr>
<td>Germany</td>
<td>7.6</td>
</tr>
<tr>
<td>Egypt</td>
<td>7.5</td>
</tr>
<tr>
<td>Japan</td>
<td>7.2</td>
</tr>
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</table>

Top 10 countries by number of diabetes people in 2013, aged 20-79
Singapore 3H Problem

**Diabetes in Singapore**

**The Big Numbers**

Diabetes is common, and increasingly so

440,000 Singaporeans had diabetes in 2014.\(^1\) The number is estimated to go up to 1 million by 2050.\(^2\)

It accounts for 10% of disease burden in Singapore.\(^3\)

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\(^1\) Extrapolation based on National Health Survey 2010, Ministry of Health

\(^2\) Saw Swee Hock School of Public Health

\(^3\) Singapore Burden of Diseases Study 2010, Ministry of Health
“How can Artificial Intelligence (AI) help primary care teams stop or slow disease progression and complication development in 3H – Hyperglycemia (diabetes), Hypertension (high blood pressure) and Hyperlipidemia (high cholesterol) patients by 20% in 5 years?”
Existing Approach: The Chronic Care Model

Disease Factors and Self-Management

- Demographics
- Genetics
- Lifestyle/Health Behavior
- Medical Care

- Modifiable factors
- Missing in healthcare system
- Account for 50% of disease causes
AI-empowered Solution Framework

- Personal Health Data
  - Food Logging
  - Activity Logging
  - Point-of-Care Self-Testing
  - Demographics
  - EHR
  - Genetics

- Medical Knowledge
  - Medical Ontologies
  - Medical Literature

- User Profiling
  - Physical Health
  - Psychological Traits
  - Stages of Behavior Change

- Risk Prediction
  - 3H and Complication Risk Scores
  - Explanation of Scores and Risk Factors

- Intervention
  - Recommendation Engine
  - Nudge Engine
  - Education and Inference
  - Chatbot

- Data Gathering
- Data Analytics
- Action Planning
Multi-resolution Food Recognition

![Diagram of multi-scale pool5 feature maps]

**Ingredients**
- Noodle
- Tomato
- Green onion
- Egg

**Cutting Method**
- Dice
- Stir-fry

**Cooking Method**
- Boil

**Recipe**

**Tomato & Egg Noodles**

**Ingredients:**
- Tomato (1)
- Egg (2)
- Noodle (100g)
- Green onion (a few)

**Cooking Steps:**
1. Cut tomato into large dices.
2. Break the shell of the eggs, put it into a bowl and stir.
3. Pour a few oil to work, heat it and then pour the eggs into work, stir-fry them.
4. Put the tomato dices into work, and stir-fry them with eggs.
Overall Taxonomy of Food Recognition

Food/Nutrition Recognition

- Visual-based
  - Classification-based
    - All food categories
      - 1000+ categories
  - Retrieval-based
    - Restaurant & hawker food categories
      - 87K dishes
- Nutrition-based
  - Sensor-based
    - Food categories independent
• Exercise has a modest, but consistent benefit on body fat reduction
  • benefit is independent of dieting
  • Med Sci Sport Exercise (2009)

• Exercise data can be tracked & obtained from various sources:
  • Mobile phones (auto tracked)
  • Various types of wearable ex./health sensors
  • Data to log: step counts, accelerometer values, heart beats & body temperatures etc.
Point-of-Care Testing
Continuous Glucose Monitoring

35g Carbs

150g Carbs

34g Carbs

120g Carbs

Dexcom
Continuous Glucose Monitoring

Abbott

Medtronic
User Profiling

- dietary patterns
- health eating index
- physical activity level
- sleep patterns

- depression rating scale
- personality type
- decision making style
- emotion regulation
- Anxiety level
- stress levels

Happy Human
1. Date of birth*

dd/mm/yyyy

2. Gender*

- Male
- Female

3. Enter your height (cm) and weight (kg) to find out your Body Mass Index (BMI).*

Height: ___ cm
Weight: ___ kg
BMI = ___ kg/m²

4. Do you have a parent, sibling and/or child diagnosed with Type 2 diabetes?*

- Yes
- No

5. Have you ever been told by your doctor that you have high blood pressure (hypertension)?*

6. On average, how much time do you spend on physical activity in a week? Examples of physical activity are housework, cycling, jogging, swimming & playing sports/games.

- Less than 100 minutes
- Between 100 and 150 minutes
- More than 150 minutes

7. How often do you drink sugary beverages? Examples of sugary beverages are soft drinks, fruit juice, yoghurt drinks, coffee, tea and bubble tea.

- 0 to 2 times per week
- 3 to 6 times per week
- 7 or more times per week

Questions 6 and 7 are optional and won't be used to assess your risk of diabetes. They are a reminder to eat healthily and exercise regularly - if you are not already doing so!
Limitations of existing models:
1. Lifestyle factors are missing
2. Based on western population and a limited age group
3. Diseases are separately modeled.
Mental & Physical Health

Cognitive Behavior Therapy

Exercise, Nutrition & Eating

Reflection Prompts to Explain

Motivational Messages & Reminders to Plan

Improving Outcome of Psychosocial Treatments by Enhancing Memory, 2014

Learning Cognitive Behavior Therapy 2015
**Nudge Engine:**
Collaborative, Dynamic, Personalized

**AdapComp/MOOClet**
github.com/kunanit/mooclet-engine

**Enhancement**
- A: 0%
- B: 100%

**Personalization**
- A: 100%
- B: 0%

**Outcome Metric**
- Dynamic Analysis
  - A: X%
  - B: 100-X%

**Dynamic Analysis**
A + ... + N
Continually add conditions

50% 50%

**Conference Proceedings**
- **Cognitive Science**
  - Cognitive Science 2010
  - J. of Exp. Psych., 2013
- **Instructional Design**
  - EDM 2015
  - IJAIED 2016
- **Bayesian Statistics & Machine Learning**
  - NIPS 2008, UAI 2013
  - ACIC 2016
- **Crowdsourcing & Human Computation**
  - CHI 2016
  - ACM LAS 2016

**HCI**

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AI for Lifestyle self-management, Validation and Empowerment (ALiVE)
Patient App: tracking functions
Patient App: Intervention functions

- **A/B Testing**
  - *Exercise!* Read here to make a plan.
  - *Ready?* Made a plan to exercise today?

- **Reminder**
  - It’s past Lunch Time. Have you eaten yet?

- **Notifications**
Clinical Platform

Diet Health

Patient

Calories | Blood Pressure | Glucose Levels

13 March, 2018 — 19 March, 2018

Susan

Age: 71
Gender: F
BMI: 31.2
Weight: 78kg
Height: 1.57m

Nutrition distribution

65%

Step

15790 steps

Food diary
13 March, 2018

Breakfast
- Fish porridge
  - Calories: 210.7 kcal
  - Carbohydrates: 32.42g
  - Protein: 13.9g
  - Fats: 2.8g

Lunch
- Economic fried bee hoon
  - Calories: 250.1 kcal
  - Carbohydrates: 45.7g
  - Protein: 5.5g
  - Fats: 4.9g
- Fried fish cake
Year 1
- **Front-end tool**: A mobile app (for patient), and a clinical platform (for primary care providers)
- **Backend AI engine**
- Benchmark the accuracy of the app-based food tracking method and the activity level classification

Year 2
- **Feasibility study**: usability and feasibility of the patient mobile app and the clinician platform
- Adjustment of the app and platform based on feasibility study feedback.

Year 3
- **Randomized Controlled Trial** in six NUPs.
- Incorporate advanced body sensors into user profiling.
- Further develop the recommendation and education engine.

Year 4
- RCT report.
- Feasibility study of the **blockchain-based** private machine learning.
- Further develop the nudge engine and chatbot.

Year 5
- Feasibility study of the improved chatbot and nudge engine.
- **Deploy the app** to the general public and the clinical platform to other primary care settings.
Stage 1: (Y1, Y2)
- one NUP
- 1,600 patients
- 6 months

Stage 2: (Y3, Y4, Y5)
- six NUP
- 39,600 patients
- 18 months
### Clinical Trial - Stage 1: Feasibility

<table>
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<td>1. The proportion of eligible patients in a typical polyclinic.</td>
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### Preliminary Outcomes

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<td>9. Change in self-reported measures including EQ-5D Quality of Life and SF-12 Physical and Mental Health, between baseline and 3 month follow-up.</td>
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Clinical Trial - Stage 2: RCT
Efficacy of intervention

<table>
<thead>
<tr>
<th>Control arm</th>
<th>Intervention arm: Level 1</th>
<th>Intervention arm: Level 2</th>
</tr>
</thead>
</table>
| • standard care  
  • no use of App; | • standard care +  
  • App-based self-tracking; | • standard care +  
  • App-based self-tracking +  
  • personalized nudging. |

### Primary Outcomes of the RCT

1. Change in blood pressure, blood sugar levels, lipid levels, and weight.
2. Change in patient risk prediction for each 3H condition.
3. Adverse outcomes in past 6 months (e.g. 3H-related hospitalizations).

### Secondary Outcomes of the RCT

4. EQ-5D Measure of Quality of Life.
5. SF-12 Physical and Mental Health.
6. Change in Lifestyle (e.g. average daily steps in past week, average daily calories consumed in past week).
7. Total health care costs in past 6 months.
Who will benefit?

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<tr>
<td><strong>Primary Care Facilities</strong></td>
<td></td>
</tr>
<tr>
<td>► Public - Polyclinics</td>
<td>20</td>
</tr>
<tr>
<td>► Private - General Practitioner Clinics</td>
<td>2,102</td>
</tr>
<tr>
<td><strong>Centre-based Care Facilities</strong></td>
<td>88</td>
</tr>
<tr>
<td><strong>Home Care Providers</strong></td>
<td>21</td>
</tr>
<tr>
<td><strong>Home Palliative Care Providers</strong></td>
<td>7</td>
</tr>
<tr>
<td><strong>Nursing Homes</strong></td>
<td>73</td>
</tr>
<tr>
<td>► Public</td>
<td>20</td>
</tr>
<tr>
<td>► Not-for-Profit</td>
<td>23</td>
</tr>
<tr>
<td>► Private</td>
<td>30</td>
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Disrupt the future of healthcare

ALiVE
(DietLens)
Team Composition

Chua Tat Seng (Professor, AI and unstructured multimodal analytics)
Ooi Wei Tsang (Associate Professor, activity analysis)
Peh Li Shiuan (Chair Professor, advanced sensor technologies)
Tan Kian Lee (Professor, blockchain-based systems and private AI)
Liang Zhenkai (Assoc Professor, security and privacy)

Chong Yap Seng (Professor, Dean School of Medicine)
Young Yee Ling, Doris (Professor, Head of Family Medicine)
Lew Yii Jen (CEO, National University Polyclinic)
Mary Chong (Assistant Professor, Nutrition Science)
Yu Rong Jun (Assistant Professor, Psychology)
A click to healthier lifestyle with DietLens

Improve your overall well-being with our AI Assistant that promotes good eating habits, advocates active lifestyles and influence positive behavioral change.

Be ALiVE

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ALiVE will conduct the **world’s largest App-based AI-empowered** personalized 3H intervention study that focuses on self-management and primary care support.
## Task dependent performance metrics (AI)

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<th>Metrics</th>
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<td>Food Recognition</td>
<td>Precision, Recall, Accuracy.</td>
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<tr>
<td>Activity Classification</td>
<td>Precision, Recall, Accuracy.</td>
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<tr>
<td>Recommendation</td>
<td>Hit ratio, Normalized Discounted Cumulative Gain (NDCG).</td>
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<tr>
<td>Nudge Engine</td>
<td>User ratings, Response ratio.</td>
</tr>
<tr>
<td>Chatbot</td>
<td>Bilingual Evaluation Understudy (BLEU), Average Task Completion Rate, Average Number of Turns in dialogue.</td>
</tr>
<tr>
<td>Risk prediction</td>
<td>Area Under the ‘receiver operating Curve’ (AUC), Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV).</td>
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### Functional Metrics

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## Outcome Indicators for the RCT

### Primary Outcomes of the RCT

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### Secondary Outcomes of the RCT

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<tr>
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<td>EQ-5D Measure of Quality of Life.</td>
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MOOClet Engine: Separates Versions, Policy, Data

Learner Interface
- Resource
  - MOOClet
    - API/ modifyVersion
    - API/ assignVersionofResource
    - API/ setPolicyandParams
    - API/ modifyVariable

Version Set
- Policy
  - API/ modifyVariable

Learner Data Store

github.com/kunanit/mooclet-engine

test.mooclet.vpal.io/moocletengine/api/
• What are you trying to do? Articulate your objectives without the use of jargons. How does it address the Challenge? Why is it difficult?

• How is it done today, and what are the limitations of current practice?

• What is new in your approach and why do you think it will be successful?

• Who should care and why?

• If your project is successful, what difference will it make? What social and/or economic impact will the success have?

• What are the risks and the payoffs?

• How much will it cost? (giving strong justifications for request exceeding S$5 million for stage 1 and/or S$20 million for stage 2 respectively)

• How long will it take?

• What are the mid-term and final "exams" to check for success? How will the success be measured?

• Additional considerations (optional; to be addressed by PI at his/her discretion)

• Other components of proposal to be highlighted, e.g. synergies of projects within proposed programme, team composition, collaboration with academia/industry, programme management (e.g. Gantt chart, project involvement structure), relevant to Singapore etc.

• Relevant rebuttal (if any) from PI and team in response to reviewers’ feedback on proposal.