Big Data AI for Personal Wellness

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OUTLINE

- NExT Research Project
- Wellness Project
- Activities: Physical and Cyber
- Diet Management: Food Recognition, Diet Recommendation & Food KG
- Wellness App: From Research to Deployment/ Validation
- Key Research Issues and Summary
Users at Center of Social Media Environment

Public

Personal -- Friends
We Utilize Multi-Channel Data

Multi-Sources of Public Data:

• Social media sources- live info streams:
  o Spontaneous User-Generated Contents (UGC)
  o Device-Generated Contents, IoT (DGC)

• Web sources:
  - Web Search Engines
  - Forums
  - E-commerce Sites

• Other data sources: offline data, domain data
• Industry data for vertical domains
Focus on real-time multi-channel unstructured data analytics
  - Among the first to explore this research in 2010

Phase I: May 2010 to Sep 2016 with a Grant of S$11 million
  - Emphasis: Technology for unstructured data analytics

Phase II: Oct 2016 to Sep 2021 with a Grant of S$12 million
  - Emphasis: Unstructured data analytics & deep insights
  - Extended to include Southampton University
Key Research Challenges

• Big Data Challenges:
  o More accurate & complete extraction & discovery of knowledge from multi-source multimodal data streams
  o Basic Research: Rich media semantics, recommendation, multimodal Chatbot, Multimodal Knowledge Graph, Trust, etc.

• Paradigm Challenges:
  o Explore alternative approaches to engage users
  o From recommendation to influence, from 2D to immersive 3D

• Transformative Applications:
  o Explore better user-system symbiosis through innovative applications
  o Wellness, Finance, Smart City
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• 6 out of 10 deaths are caused by chronic diseases world-wide

• 80% of the chronic diseases happen in low and middle income countries.
Projected foregone national income due to major chronic diseases

$558 billion: the estimated amount China will forego in national income over the next 10 years as a result of premature deaths caused by major chronic diseases.

Source: Preventing Chronic Diseases a Vital Investment, World Health Organization
The risk factors are widespread:

1. **Unhealthy diet**
2. **Physical inactivity**
3. **Tobacco use** (action is taken)

Each year:

- 2.6 million people die of being overweight or obese
- 4.4 million people die of raised total cholesterol levels
- 7.1 million people die of raised blood pressure
Lifestyle + Environment > Medicine

- 20% - genetics
- 10% - medical healthcare

- 50% - lifestyle
- 20% - environment

70% Is lifestyle
It is Possible to reduce cost of care while Improving the quality of life
Three Key Aspects Characterizing Users’ Lifestyle

- Eating behavior
- Treatment & Tests
- Exercise

Lifestyle Management
Framework for Wellness App

Analytic

Critical Diseases
- Obesity
- Diabetes
- Sleep Disorder
- Depression, etc...

Knowledge
- Wellness Knowledge

User Data
- Food Intake & Habits
- Activities (Physical & Cyber)
- Others: Treatment & Test; Environment Data
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Effects of Physical Activity

AEROBIC EX. →
- RHR
- VO₂ Max
- SV

ANAEORBIC EX. →
- Strength
- PCSA
- Neural Drive

Resting Heart Rate (RHR)
Maximal Oxygen Consumption (VO₂ Max)
Stroke Volume (SV)

Strength
Neural Drive
Physiologic Cross-Sectional Area (PCSA)
The Role of Exercise

- Exercise has a **modest, but consistent benefit** on body fat reduction
  - benefit is independent of dieting

- Amount of exercise required? 30 mins/day?
  - *ACSM 2009 Guidelines*

- Walking ≥4 hrs/wk protective of weight gain over 10 yrs

- ≥5 hrs/wk vigorous activity gained 0.5 kg less
Exercise data can be tracked & obtained from various sources:
- Mobile phones (auto tracked)
- Various types of wearable exercise/health sensors

Segmentation and classification of exercise types
Tracking of Cyber Activities -1

Eating behavior

Exercise
Tracking of Cyber Activities -2

Medical Tests

Treatment

Rose @Rosie_Tomato · Jan 10
Approx 6 1/2 hours post steroid injection #bgnow sitting at 179. Higher than I’d like but better than I expected.

John Boyle @StressedDiabot · Nov 29
Injection #4 today on top of 200% TBR. Lost count of how many in last 36h. 2nd set change too. It really is Black Friday! #gbdoc #BGNow 16.2
Unify Social Media & Wearable Sensors for Physical Attributes Inference

Weight Fluctuation Trend (BMI Trend)

• Combination of data sources perform the best for BMI prediction (F1 = 0.246)
Converting Social Media Posts into Activity Timeline

What do users eat?
What do users share?
How much do they exercise?
Where do users go?

Earls Restaurant

User Health Profile

Diagnosed Diabetes 11
Activity Walking 5km
Health BG Check 5.8
Food Dinner Low-caloric
Health BG Check 5.8
Health BG Check 34.8

Kelley-Below-Seven @A1CBelowSeven · Jan 18
Eeek!!! #bgnow 356!!! I can't remember the last time I was so high. cake!

DISTANCE: 38.26 km
AVG. SPEED: 20.7 km/h
CALORIES: 193.5 kcal
AVG. HEART RATE: 163
MAX ALTITUDE: 367 m
TOTAL ASCENT: 242 m
WEATHER: Mostly cloudy

DURATION: 1h 50m: 44s
MAX SPEED: 48.6 km/h
MAX HEART RATE: 190
MAX ALTITUDE: 401 m
TOTAL DESCENT: 258 m

Weather data provided by AccuWeather.com
Example of the Constructed Timeline

Figure 1: An example personal health event timeline. A tweet can include information corresponding to different categories is represented by different colors.

Cyber Event Types | F$_1$-measure
--- | ---
Food & Nutrition | 85.99
Exercise & Activities | 88.07
Health & Wellness | 77.56
Average | 84.79
PWE detection is the first important step towards understanding online users wellness.
Towards Wellness User Profiling

User profile

- Wellness profile
  - Diabetes, Obesity, Sleep, Depression, ...

- Mobility profile
  - Movement Patterns, Venue Preferences

- Demographic profile
  - Age, Gender, Interests, Personality, Occupation, ...

Wellness (diabetes, obesity, depression)

User Demography detection

User Community Detection

Sentiment Analysis

Gaming (addiction detection)
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## Dietary Tracking App

<table>
<thead>
<tr>
<th>App Name</th>
<th>Record by Photo</th>
<th>Food Photo Recognition</th>
<th>Record by Search</th>
<th>Record by barcode scan</th>
<th>Record by free text</th>
<th>Rating out of 5</th>
<th># Rating</th>
<th>Launch Time</th>
<th># Download</th>
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<tbody>
<tr>
<td>MyFitnessPal</td>
<td>N</td>
<td>NA</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>4.6</td>
<td>1,000,000</td>
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<tr>
<td>FatSecret</td>
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<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>4.4</td>
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<td>2007</td>
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<td>Noom Coach</td>
<td>N</td>
<td>NA</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>4.3</td>
<td>166,000</td>
<td>2010</td>
<td>10,000,000</td>
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<tr>
<td>Lose It!</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>4.4</td>
<td>55,000</td>
<td>2011</td>
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<td>Sparkpeople</td>
<td>N</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>22,000</td>
<td>2012</td>
<td>1,000,000</td>
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<td>MyNetDiary</td>
<td>N</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>4.5</td>
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<td>2010</td>
<td>1,000,000</td>
</tr>
<tr>
<td>MyPlate</td>
<td>N</td>
<td>NA</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>4.6</td>
<td>16,000</td>
<td>2010</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>
Complex Problems of Food Recognition

Examples of dishes with the same ingredients but different cutting and cooking methods.

- Deep fry → high fat
- Heavy gravy → high sodium
- Finely diced → easy to digest (high GI)
Given a food image, we aim to retrieve its recipe with rich attributes: ingredients, cutting and cooking methods, and nutrition values.

The sauce and gravy contents can be obtained from recipe, but not image recognition.
The nutrition of the dish can be synthesized by combining the nutrition and amount of ingredients.

From food in-take to food ingredients & nutrition trends
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- Activities: Physical and Cyber
- **Diet Management**: Food Recognition, Diet Recommendation & Food KG
- Wellness App: From Research to Deployment/Validation
- Key Research Issues and Summary
Food Analysis:
From Food to Nutrition and Diseases

• Given info on food in-take, we next need to infer nutritional values and possible wellness effects
Given One Day Food Intake of Person-X

How good it is?

- **Breakfast**
  - **Milk**: 1 cup 250ml
  - **White bread**: 2 slices
  - **Egg**: 1 egg
  - **Banana**: 1 medium size

- **Lunch**
  - **White rice**: 1 bowl
  - **Stir fried pork with cabbage**: 1 small plate
  - **Grilled fish**: 1 serving piece
  - **Orange**: 1 medium size

- **Dinner**
  - **Beef noodle**: 1 standard bowl
  - **Spinach**: 1 small plate
Categories of Nutrients

Macronutrients and Micronutrients

MACRONUTRIENTS

- Proteins
- Carbohydrates
- Fats

MICRONUTRIENTS

- Vitamins
- Minerals
- Trace elements

WATER
## Micronutrients

### Water Soluble Vitamins
- Vitamin B6
- Vitamin B2 - Riboflavin
- Vitamin B1 - Thiamin
- Vitamin B12 - Niacin
- Vitamin C
- Pantothenic Acid
- Biotin
- Folic Acid

### Essential Minerals
- Calcium
- Sulphur
- Iron
- Potassium
- Phosphorus
- Sodium
- Magnesium

### Fat Soluble Vitamins
- Vitamin A
- Vitamin D
- Vitamin K
- Vitamin E

### Trace Elements
- Chromium
- Cobalt
- Zinc
- Selenium
- Iodine
- Fluoride
- Manganese
- Silicon
- Boron
- Copper
### Macronutrients: Required Amount

*But more is not necessarily better*

<table>
<thead>
<tr>
<th>Source of goal a</th>
<th>Child 1-3</th>
<th>Female 4-8</th>
<th>Male 4-8</th>
<th>Female 9-13</th>
<th>Male 9-13</th>
<th>Female 14-18</th>
<th>Male 14-18</th>
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<tbody>
<tr>
<td><strong>Calorie level(s) assessed</strong></td>
<td>1,000</td>
<td>1,200</td>
<td>1,400, 1,500</td>
<td>1,600</td>
<td>1,800</td>
<td>1,800</td>
<td>2,200, 2,800, 3,200</td>
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<tr>
<td><strong>Macronutrients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Protein, g</td>
<td>RDA</td>
<td>13</td>
<td>19</td>
<td>19</td>
<td>34</td>
<td>34</td>
<td>46</td>
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<tr>
<td>Protein, % kcal</td>
<td>AMDR</td>
<td>5-20</td>
<td>10-30</td>
<td>10-30</td>
<td>10-30</td>
<td>10-30</td>
<td>10-30</td>
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<tr>
<td>Carbohydrate, g</td>
<td>RDA</td>
<td>130</td>
<td>130</td>
<td>130</td>
<td>130</td>
<td>130</td>
<td>130</td>
</tr>
<tr>
<td>Carbohydrate, % kcal</td>
<td>AMDR</td>
<td>45-65</td>
<td>45-65</td>
<td>45-65</td>
<td>45-65</td>
<td>45-65</td>
<td>45-65</td>
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<tr>
<td>Dietary fiber, g</td>
<td>14g/1,000 kcal</td>
<td>14</td>
<td>16.8</td>
<td>19.6</td>
<td>22.4</td>
<td>25.2</td>
<td>25.2</td>
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<tr>
<td>Added sugars, % kcal</td>
<td>DGA</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
</tr>
<tr>
<td>Saturated fat, % kcal</td>
<td>DGA</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
<td>&lt;10%</td>
</tr>
<tr>
<td>Linoleic acid, g</td>
<td>AI</td>
<td>7</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>12</td>
<td>11</td>
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<tr>
<td>Linolenic acid, g</td>
<td>AI</td>
<td>0.7</td>
<td>0.9</td>
<td>0.9</td>
<td>1</td>
<td>1.2</td>
<td>1.1</td>
</tr>
</tbody>
</table>
US Dietary Guidelines

New Food Pyramid

- Limit intake of red meat & butter
- Limit high glycemic foods

Low fat dairy, and soy milk
1-2 servings

Water, 5-8 glasses

Legumes
1-2 servings

Whole grains
4-8 servings

Vegetables
3-6 servings

Multiple vitamins for most

Eggs, fish, poultry, and plant proteins
1-2 servings

Nuts and seeds
1-2 servings

Plant oils
2-4 servings

Fruits
2-4 servings

Daily exercise and weight control
UK Dietary Guidelines

The Food Pyramid

Foods and drinks high in fat, sugar and salt

For adults, teenagers and children aged five and over

NOT every day

Maximum once or twice a week

Fats, spreads and oils

In very small amounts

Meat, poultry, fish, eggs, beans and nuts

2 Servings a day

Milk, yogurt and cheese

3 Servings a day

Wholemeal cereals and breads, potatoes, pasta and rice

3-5 Servings a day

Vegetables, salad and fruit

5-7 Servings a day
## Chinese Dietary Guidelines (2016)

### Daily Food Intake Amounts

<table>
<thead>
<tr>
<th>Food Group</th>
<th>Daily Intake (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt</td>
<td>&lt;6克</td>
</tr>
<tr>
<td>Oil</td>
<td>25~30克</td>
</tr>
<tr>
<td>奶及奶制品</td>
<td>300克</td>
</tr>
<tr>
<td>大豆及坚果类</td>
<td>25~35克</td>
</tr>
<tr>
<td>畜禽肉</td>
<td>40~75克</td>
</tr>
<tr>
<td>水产品</td>
<td>40~75克</td>
</tr>
<tr>
<td>蛋 类</td>
<td>40~50克</td>
</tr>
<tr>
<td>蔬菜类</td>
<td>300~500克</td>
</tr>
<tr>
<td>水果类</td>
<td>200~350克</td>
</tr>
<tr>
<td>谷薯类</td>
<td>250~400克</td>
</tr>
<tr>
<td>全谷物和杂豆</td>
<td>50~150克</td>
</tr>
<tr>
<td>饮料</td>
<td>50~100克</td>
</tr>
<tr>
<td>水</td>
<td>1500~1700毫升</td>
</tr>
</tbody>
</table>
6 Food Groups ➔
30 USDA Food Categories

Grain group
- 1 Total grain
- 2 Whole grain
- 3 Non-whole grain

Veg. group
- 4 Total vegetables
- 5 Dark green leafy vegetables
- 6 Deep-yellow vegetables
- 7 White potatoes
- 8 Other starchy vegetables
- 9 Tomatoes
- 10 Other vegetables

Fruit group
- 11 Total fruits
- 12 Citrus fruits, melons, and berries
- 13 Other fruits

Dairy group
- 14 Total dairy
- 15 Milk
- 16 Yogurt
- 17 Cheese

Meat & beans
- 18 Meat, poultry, fish
- 19 Meat (beef, pork, veal, lamb, game)
- 20 Organ meats (meat, poultry)
- 21 Frankfurters, sausage, luncheon meats
- 22 Poultry

Pyramid tip
- 28 Discretionary fat
- 29 Added sugars
- 30 Alcohol
Given One Day Food Intake of Person-X

How good it is?

- **Breakfast**
  - Milk: 1 cup 250ml
  - White bread: 2 slices
  - Egg: 1 egg
  - Banana: 1 medium size

- **Lunch**
  - White rice: 1 bowl
  - Stir fried pork with cabbage: 1 small plate
  - Grilled fish: 1 serving piece
  - Orange: 1 medium size

- **Dinner**
  - Beef noodle: 1 standard bowl
  - Spinach: 1 small plate

We can now analyze the Quality of Person-X’s Food intake.
Person-X’s One Day Energy Intake Analysis

- 4 calories $\leftrightarrow$ 1g of Carbohydrate
- 4 calories $\leftrightarrow$ 1g of Protein
- 9 calories $\leftrightarrow$ 1g of Fat

<table>
<thead>
<tr>
<th></th>
<th>Food intake</th>
<th>Reference</th>
<th>Difference</th>
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<tbody>
<tr>
<td>Calories</td>
<td>1253</td>
<td>1200 cal/d</td>
<td>53</td>
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<tr>
<td>Carbohydrate</td>
<td>160</td>
<td>130 g/d</td>
<td>30</td>
</tr>
<tr>
<td>Fat/g</td>
<td>45</td>
<td>50 g/d</td>
<td>-5</td>
</tr>
<tr>
<td>Protein</td>
<td>53</td>
<td>56 g/d</td>
<td>-3</td>
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</table>
### Person-X’s One Day Micronutrients Analysis

<table>
<thead>
<tr>
<th>Micronutrients</th>
<th>Xiaoyan’s intake</th>
<th>Reference</th>
<th>Difference</th>
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</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>747.5</td>
<td>900 ug/d</td>
<td>-152.5</td>
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<tr>
<td>Vitamin C</td>
<td>153.599</td>
<td>90 mg/d</td>
<td>63.599</td>
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<tr>
<td>Calcium</td>
<td>739.9</td>
<td>1000 mg/d</td>
<td>-260.1</td>
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<tr>
<td>Vitamin D</td>
<td>9.75</td>
<td>15 ug/d</td>
<td>-5.25</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>5.085</td>
<td>15 mg/d</td>
<td>-9.915</td>
</tr>
<tr>
<td>Iron</td>
<td>5.995</td>
<td></td>
<td>5.995</td>
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<tr>
<td>Thiamin</td>
<td>1.418</td>
<td>1.2 mg/d</td>
<td>0.218</td>
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<tr>
<td>Riboflavin</td>
<td>1.837</td>
<td>1.3 mg/d</td>
<td>0.937</td>
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<tr>
<td>Niacin</td>
<td>20.145</td>
<td>16 mg/d</td>
<td>4.145</td>
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<tr>
<td>Vitamin B6</td>
<td>2.292</td>
<td>1.3 mg/d</td>
<td>0.992</td>
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<tr>
<td>Potassium</td>
<td>2.929</td>
<td>4.7 g/d</td>
<td>-1.771</td>
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<tr>
<td>Folate</td>
<td>500.9</td>
<td>400 ug/d</td>
<td>100.9</td>
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<tr>
<td>Vitamin B12</td>
<td>9.762</td>
<td>2.4 ug/d</td>
<td>7.362</td>
</tr>
</tbody>
</table>

**Shortage of Vitamin A, D, E and Calcium**
### Vitamin A
- Essential for vision
- Keeps tissues and skin healthy

### Vitamin D
- Helps ensure dietary calcium is absorbed into the body
- Helps maintain normal blood levels of calcium and phosphorus, which strengthen bones
- Helps form teeth and bones
- Supplements can reduce the number of nonvertebral fractures

### Vitamin E
- Acts as an antioxidant, neutralizing unstable molecules that can damage cells
- Protects vitamin A and certain lipids from damage
- Builds and protects bones and teeth
- Helps with muscle contractions and relaxation, blood clotting, and nerve impulse transmission
- Plays a role in hormone secretion and enzyme activation
- Helps maintain healthy blood pressure

### Calcium
- Builds and protects bones and teeth
- Helps with muscle contractions and relaxation
- Helps maintain normal blood levels of calcium and phosphorus, which strengthen bones
- Plays a role in hormone secretion and enzyme activation
- Helps maintain healthy blood pressure

---

**Selected food sources of vitamin A and beta carotene**

<table>
<thead>
<tr>
<th>FOOD</th>
<th>INTERNATIONAL UNITS</th>
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<tbody>
<tr>
<td>Carrots, boiled, 1/2 cup</td>
<td>11,286</td>
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<tr>
<td>Spinach, frozen, 1/2 cup</td>
<td>9,558</td>
</tr>
<tr>
<td>Kale, frozen, 1/2 cup</td>
<td>2,063</td>
</tr>
<tr>
<td>Prickly pear, 1 cup</td>
<td>1,785</td>
</tr>
<tr>
<td>Milk, fortified, 8 ounces</td>
<td>524</td>
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</table>

**Selected food sources of vitamin D**

<table>
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<th>INTERNATIONAL UNITS</th>
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</thead>
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<tr>
<td>Salmon, pink, cooked, 3 ounces</td>
<td>444</td>
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<tr>
<td>Tuna fish, canned in oil, drained 3 ounces</td>
<td>229</td>
</tr>
<tr>
<td>Sardine, canned in oil, drained 8 ounces</td>
<td>165</td>
</tr>
<tr>
<td>Milk, fortified, 8 ounces</td>
<td>9</td>
</tr>
<tr>
<td>Orange juice, fortified, 8 ounces</td>
<td>7.6</td>
</tr>
<tr>
<td>Egg, whole, cooked, scrambled 1 large</td>
<td>6.2</td>
</tr>
<tr>
<td>Cheddar cheese, 1 ounce</td>
<td>5</td>
</tr>
<tr>
<td>Frozen yogurt, flavor other than chocolate, 8 ounces</td>
<td>94</td>
</tr>
</tbody>
</table>

**Selected food sources of vitamin E**

<table>
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<th>FOOD</th>
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</tr>
</thead>
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<tr>
<td>Sunflower seeds, dry roasted, 1 ounce</td>
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</tr>
<tr>
<td>Almonds, dry roasted, 1 ounce</td>
<td>9</td>
</tr>
<tr>
<td>Sunflower oil, 1 tablespoon</td>
<td>7.6</td>
</tr>
<tr>
<td>Safflower oil, 1 tablespoon</td>
<td>6.2</td>
</tr>
<tr>
<td>Peanut butter, 2 tablespoons</td>
<td>3.9</td>
</tr>
</tbody>
</table>

**Selected food sources of calcium**

<table>
<thead>
<tr>
<th>FOOD</th>
<th>MILLIGRAMS (MG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yogurt, plain, nonfat, 8 ounces</td>
<td>488</td>
</tr>
<tr>
<td>Orange juice, calcium-fortified, 8 ounces</td>
<td>349</td>
</tr>
<tr>
<td>Yogurt, fruit, nonfat, 8 ounces</td>
<td>345</td>
</tr>
<tr>
<td>Milk, nonfat, 8 ounces</td>
<td>316</td>
</tr>
<tr>
<td>Tofu, firm, made with calcium sulfate, 1/2 cup</td>
<td>253</td>
</tr>
<tr>
<td>Salmon, pink, canned, with bones 3 ounces</td>
<td>183</td>
</tr>
<tr>
<td>Kale, boiled, drained, 1 cup</td>
<td>94</td>
</tr>
</tbody>
</table>
Recipes that includes the needed nutrition

- Mined from large recipe dataset and recommended based on Person-X’s food log and taste

Salmon and Kale:
Vitamin A, Calcium

Egg with sunflower oil and nuts: Vitamin D and Vitamin E

Carrot and Green Chill: Vitamin A
OUTLINE

- NExT Research Project
- Wellness Project
- Activities: Physical and Cyber
- **Diet Management:** Food Recognition, Diet Recommendation & Food Knowledge Graph
- Wellness App: From Research to Deployment/ Validation
- Key Research Issues and Summary
Key Components of Food-Nutrition-Disease Knowledge Graph

Basic structured knowledge about Food, Nutrition, Health
- From national institutions like FDA, USDA

Relations between Nutrition and Disease
- From Scientific literatures and latest medical reports

Interaction between nutrients
- From Scientific literatures and latest medical reports

Together with Dietary Guidance
**Food, Nutrients and Health**

- Basic Structured Nutrition Knowledge published by national institutes (FDA, USDA)

---

**Fruits**

<table>
<thead>
<tr>
<th>Serving Size (gram weight/ounce weight)</th>
<th>Calories</th>
<th>Calories from Fat</th>
<th>Total Fat</th>
<th>Sodium</th>
<th>Potassium</th>
<th>Total Carbohydrate</th>
<th>Dietary Fiber</th>
<th>Sugars</th>
<th>Protein</th>
<th>Vitamin A</th>
<th>Vitamin C</th>
<th>Calcium</th>
<th>Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>130</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>260</td>
<td>34</td>
<td>5</td>
<td>20</td>
<td>25g</td>
<td>1g</td>
<td>2%</td>
<td>8%</td>
<td>2%</td>
</tr>
<tr>
<td>1 Large (242 g/8 oz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avocado</td>
<td>50</td>
<td>35</td>
<td>4.5</td>
<td>7</td>
<td>140</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>0g</td>
<td>1g</td>
<td>0%</td>
<td>4%</td>
<td>0%</td>
</tr>
<tr>
<td>California, 1/5 medium (30 g/1.1 oz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Banana</td>
<td>110</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>450</td>
<td>13</td>
<td>3</td>
<td>12</td>
<td>19g</td>
<td>1g</td>
<td>2%</td>
<td>15%</td>
<td>0%</td>
</tr>
<tr>
<td>1 medium (120 g/4.5 oz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cantaloupe</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>240</td>
<td>12</td>
<td>1</td>
<td>4</td>
<td>11g</td>
<td>1g</td>
<td>120%</td>
<td>80%</td>
<td>2%</td>
</tr>
<tr>
<td>1/4 medium (114 g/4.8 oz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grapefruit</td>
<td>60</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>160</td>
<td>15</td>
<td>8</td>
<td>2</td>
<td>11g</td>
<td>1g</td>
<td>35%</td>
<td>100%</td>
<td>4%</td>
</tr>
<tr>
<td>1/2 medium (154 g/5.5 oz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grapes</td>
<td>90</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>240</td>
<td>23</td>
<td>8</td>
<td>1</td>
<td>20g</td>
<td>0g</td>
<td>0%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>3/4 cup (126 g/4.5 oz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Honeydew Melon</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>210</td>
<td>12</td>
<td>4</td>
<td>1</td>
<td>11g</td>
<td>1g</td>
<td>2%</td>
<td>45%</td>
<td>2%</td>
</tr>
<tr>
<td>1/10 medium melon (134 g/4.8 oz)</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>90</td>
<td>10</td>
<td>2</td>
<td>10</td>
<td>450</td>
<td>20</td>
<td>16</td>
<td>4</td>
<td>13g</td>
<td>1g</td>
<td>2%</td>
<td>240%</td>
<td>4%</td>
</tr>
<tr>
<td>2 medium (148 g/5.3 oz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Lemon</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>75</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>2g</td>
<td>0g</td>
<td>0%</td>
<td>40%</td>
<td>2%</td>
</tr>
<tr>
<td>1 medium (48 g/2.1 oz)</td>
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</tr>
<tr>
<td>Lime</td>
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<td>0</td>
<td>0</td>
<td>75</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>8g</td>
<td>0g</td>
<td>0%</td>
<td>35%</td>
<td>0%</td>
</tr>
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<td>1 medium (67 g/2.4 oz)</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Nectarine</td>
<td>60</td>
<td>5</td>
<td>0.5</td>
<td>1</td>
<td>250</td>
<td>15</td>
<td>2</td>
<td>8</td>
<td>11g</td>
<td>1g</td>
<td>8%</td>
<td>15%</td>
<td>0%</td>
</tr>
<tr>
<td>1 medium (140 g/5.6 oz)</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td>80</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>250</td>
<td>19</td>
<td>3</td>
<td>12</td>
<td>14g</td>
<td>1g</td>
<td>2%</td>
<td>130%</td>
<td>6%</td>
</tr>
<tr>
<td>1 medium (154 g/5.5 oz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peach</td>
<td>60</td>
<td>0</td>
<td>0.5</td>
<td>1</td>
<td>230</td>
<td>15</td>
<td>5</td>
<td>2</td>
<td>13g</td>
<td>1g</td>
<td>6%</td>
<td>15%</td>
<td>0%</td>
</tr>
<tr>
<td>1 medium (147 g/5.3 oz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Huge amount of knowledge from Books, Reference Guides, & Research Papers
Interaction between nutrients
From Scientific Literature

A Harvard Medical School Special Health Report

Making Sense of Vitamins and Minerals
Choosing the foods and nutrients you need to stay healthy

Having too much of one major mineral can result in a **deficiency** of another. **Calcium** binds with excess sodium in the body and is excreted when the body senses that **sodium** levels must be lowered. That means that if you ingest too much sodium through table salt or processed foods, you could end up losing needed calcium as your body rids itself of the surplus sodium. Likewise, too much **phosphorus** can hamper your ability to absorb **magnesium**. These sorts of imbalances are usually caused by overloads from supplements, not food sources.

- Many examples
Towards Building Food Knowledge Graph

- To build KG that encodes knowledge of:
  - Food $\rightarrow$ Nutrients
  - Food $\rightarrow$ Diseases /Health (via Nutrients)
  - Interactions between Nutrients

- Knowledge can be mined from Books, Reference Guides, & Research Reports/Papers
  - Classical Info Extraction and Relation Extraction Problems, with Taxonomy construction
  - Need to collect a complete set of such resources
  - Build up one as test set for research

- Recipes analysis to discover:
  - Combinations of ingredients that are tasty, nutritious
  - Replaceable between different ethnic food

- Start with English, extend to Chinese later
KG as Basis to Lifestyle Analysis and Recommendation: Diet and Nutrition

Personal History: Taste and nutrition profile

Nutrition Knowledge Graph

Taste based recommendation
Recipe Mining

Context based recommendation: Geolocation, Season, Food Availability, Food production

Personalized recommendation based on Disease Condition and Bio Profile
OUTLINE

- NExT Research Project
- Wellness Project
- Activities: Physical and Cyber
- Diet Management: Food Recognition, Diet Recommendation & Food Knowledge Graph
- Wellness App: From Research to Deployment/Validation
- Key Research Issues and Summary
Our Application: DietLens

Food recognition
Recognize a dish photo through deep learning tech

Food and activity diary
Easy to record your everyday diet, extract daily activity from your smartphone

Analysis report
Analyze calories/nutrition/GI from photo
Generate dietary health report

Bespoke recommendation
Combining medical knowledge graph, personal profile to customize recommendation & encouragement

Gamification
Small incremental task and targets to help earn badges and achievements milestone
Build on around 125k food images and growing

Now support 250+ local food recognition
Adding more as we progress
A Wellness Ecosystem

- Knowledge Graph
- Social Media
- Doctor
- Bespoke Recommendation

1. Working with 2 institutions:
   - National University of Hospital System (NUHS)
   - Singapore Institute of Clinical Sciences, A*Star

2. Working towards deployment and validation in near future

• Doctor 2 Doctor Network
• Doctor 2 User Network
• National Health Monitoring Network
OUTLINE

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- Key Research Issues and Summary
Key Research Issues

- Deep-Learning based Food Image Recognition
  - Must have wide coverage and high accuracy

- KG constructions from reliable unstructured resources
  - Construct KG for food -> nutrition -> diseases
  - Mine from various knowledge sources: books, research reports & papers
  - Incorporate Western and Eastern knowledge of food

- Mine users’ physical and cyber activities from multiple data sources

- Recommendation and influence of positive lifestyle changes

- Deployment and Validation at Large-Scale
  - Work with hospitals and wellness research groups
Paradigm Change

What we are building...

Is not just a Food App
Nor it is an Exercise Tracking App

It is a Lifestyle App;
A Lifestyle Coach;
A National Health Monitor
“Digital Health feels like the PC industry in the early '80's.”

John Sculley – Former CEO of Apple and PepsiCo

We are on a long-term mission towards personal wellness, we welcome collaboration on multiple topics

THANKS