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Data Science for Smart Cities, Smart Nations

LIM Ee-Peng

Living Analytics Research Center
Singapore Management University



LARC
LIVING ANALYTICS
RESEARCH CENTRE

Strategic Partner:

**Carnegie
Mellon
University**

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Data Science

Data science, also known as **data-driven science**, is an interdisciplinary field of scientific methods, processes, and systems to extract knowledge or insights from data in various forms, either structured or unstructured, similar to data mining. (Wikipedia)

Data Science in LARC Research

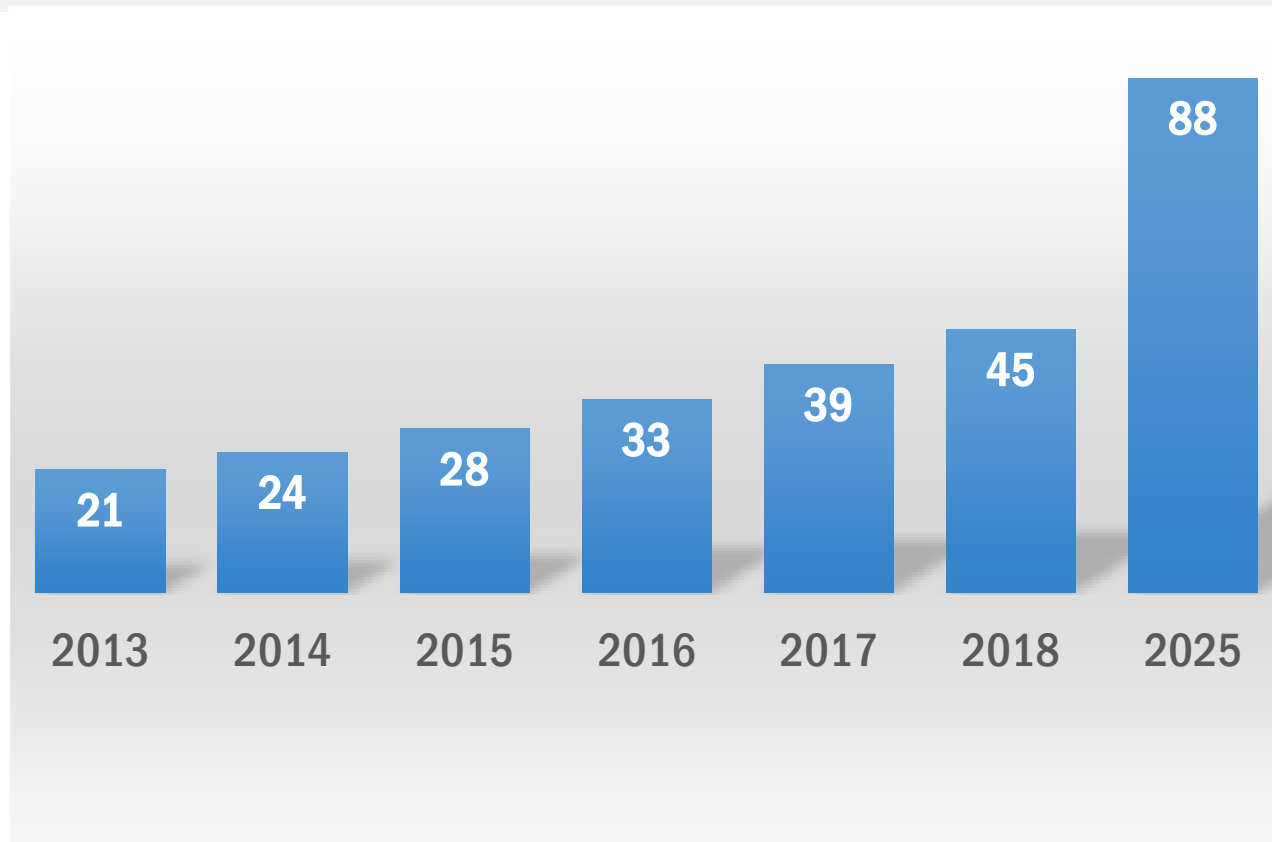
- Social and Urban Data Sensing
- Socio-Physical Analytics
- Analytics-Driven Social Activation

Smart Nation/City

A **smart nation/city** is one that uses information and communication technologies to **increase operational efficiency**, **share information with the public** and **improve both the quality of government services and citizen welfare**.

<http://internetofthingsagenda.techtarget.com/definition/smart-city>

Number of Smart Cities in the World

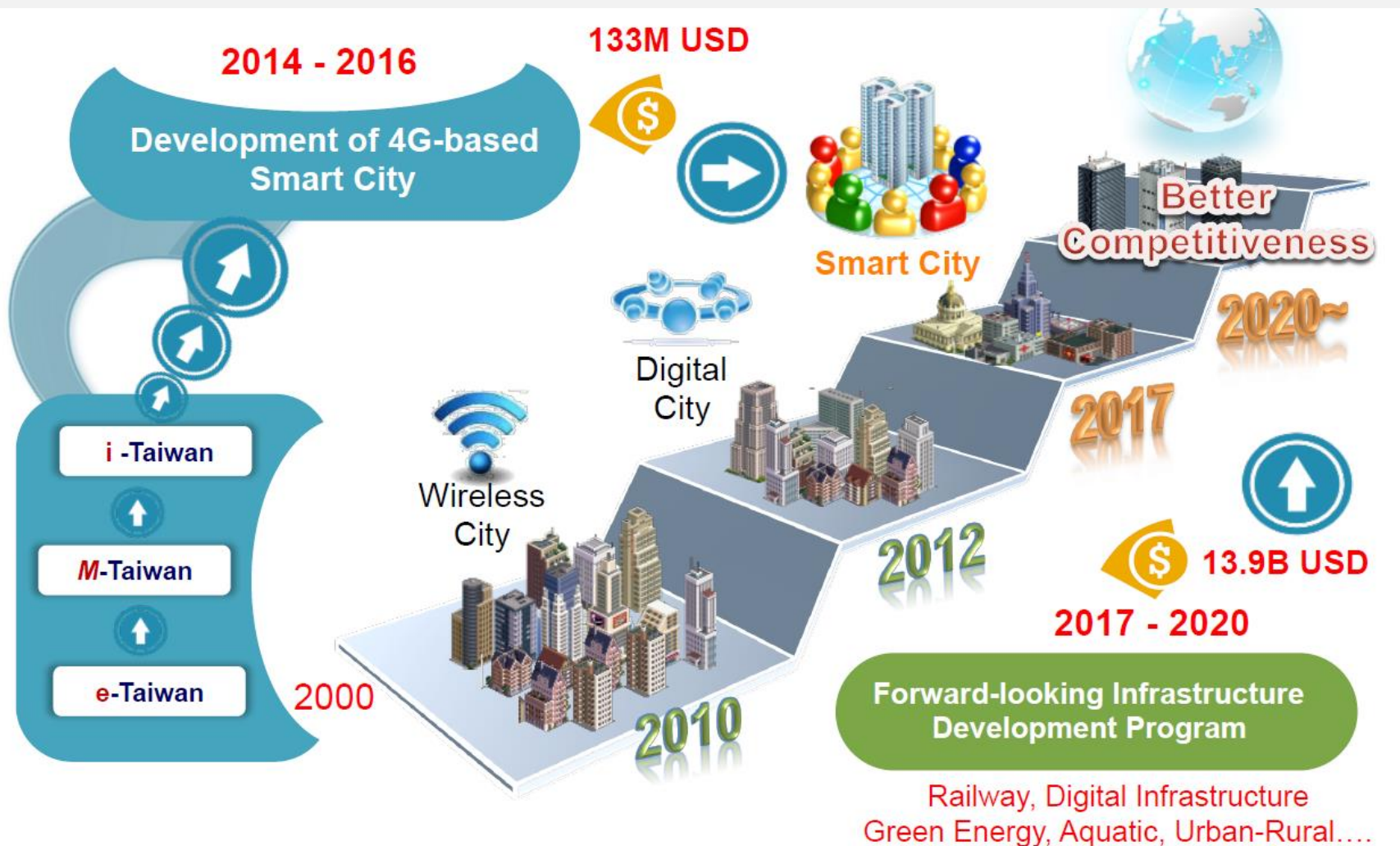


From:



IHS Technology
Information. Analytics. Expertise.

Taiwan's Smart City Effort

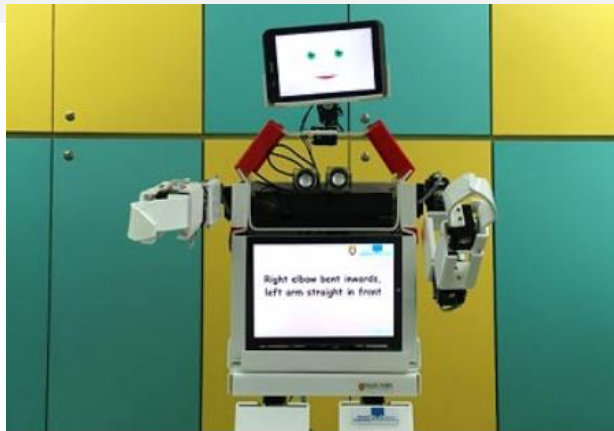


Singapore Smart Nation Effort



Self-Driving Vehicles (SDVs): Future of Mobility in Singapore

Find out how self driving vehicle technology can support mobility on demand and provide efficient transportation in the face of existential constraints.



Assistive Technology, Analytics and Robotics for Aging and Healthcare

Assistive tech can potentially revolutionise healthcare in Singapore. See how the usage of robotics in healthcare can help seniors and those with disabilities.



National Steps Challenge: An App towards Healthy and Active Lifestyle

The National Steps Challenge saw Singaporeans living a healthier lifestyle by walking more daily using wearable tech with steps tracker app.

Why Smart Cities/Nations?

Government Needs

Infrastructure for smart businesses Sharing economy Intelligent government

Information savvy workforce National security

Data
Science

Community development

Transportation Art
Housing Health
Education

Citizen Needs

Living Analytics Research Centre @ SMU

Mission:

To Develop Data Science Technologies that Build Personalized & Participatory Smart Cities/Nations for Better Social & Economic Well Being

3 main goals

- To enhance people's well-being with personalized intelligent technologies
- To empower public agencies with active citizenry and urban knowledge and insights
- To create national R&D platform) smart city/nation research and technology platforms for innovation

Citizen Focuses

Clothings Food Housing Transport
衣食住行

LARC Domains:

Career Food Housing Transport
業食住行



Jobs and Skills Intelligence

Career Coaching, Skill Training



Smart Consumption and Healthy Lifestyle

Healthy Dining, Active Lifestyle



Urban and Community Liveability

Social Activation, Activities & Events



Personalized Urban Mobility

Public Transportation, Urban Crowd Sourcing

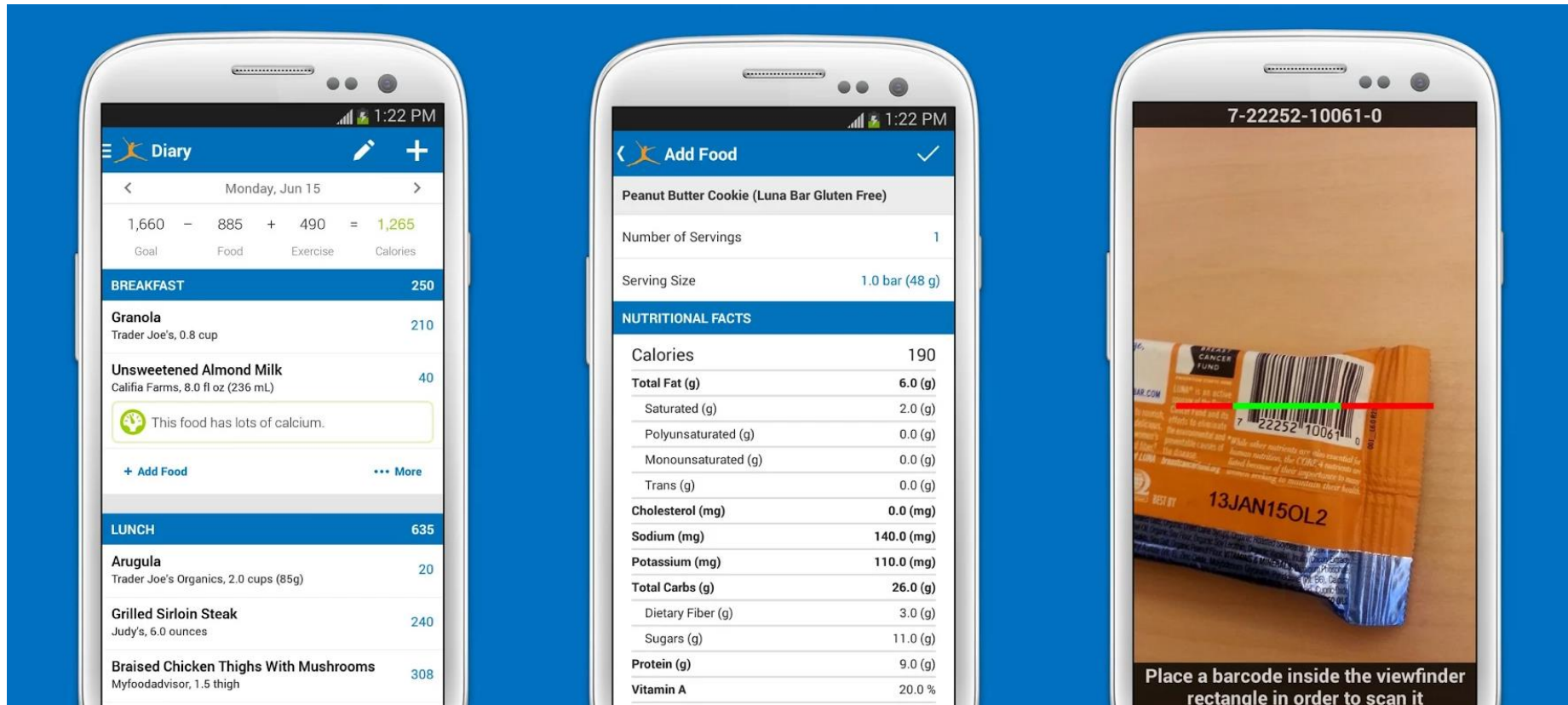
Smart Consumption and Healthy Lifestyle

Shaping Our Dining Behavior in a Food Paradise

- (a) Healthy Eating Behavior Analysis
- (b) Food AI

Food Journal Apps

Mobile food journals as self-administered behavioral change



Effectiveness in Weight Loss by Food Journal Users



Do Food Journal App Users Eat Healthy?

Promoting mindfulness,
leading to healthier choices



Mindful to eat less
vs.
Mindful to eat healthy

How Are Food Journaler Compared With Others?



VS



Scientist's Notion of Healthy Eating

Scientist's notion of healthy eating is based on individual food components and portion sizes.

See dietary guidelines:
MyPlate
EatWell
Eat for Health

The eatwell plate

Use the eatwell plate to help you get the balance right. It shows how much of what you eat should come from each food group.



Public Health England in association with the Welsh Government, the Scottish Government and the Food Standards Agency in Northern Ireland



Food Journal App Users are More Health Conscious



A recent survey (Cordeiro et al. 2015) suggests that a vast number of food journalers (past and present) generally agree with experts about the notion of healthy eating.

E.g., eat more fruits and vegetables, lean meat, and balanced diets.

Our Study

Large online observational data

**Healthy eating outcomes of online food journalers
vs offline benchmarks**

**Journaling or Sociodemographics matters more in
healthy eating**

Data

6.5M diary entries
72K unique food items
1.9M meals
9.9K users
Oct 2014 - Mar 2015

Annotated
Food Diary
Data



Removing outliers
and extracting
portion size

Data
Preprocessing

8.8K user profiles

Public
User
Profiles



ANALYSIS

FOOD DIARY DATA

9.9K
MFP Users

Record at least 7 days of
diary

8.3K
Active MFP Users

RQ 1

FOOD DIARY + PROFILE DATA

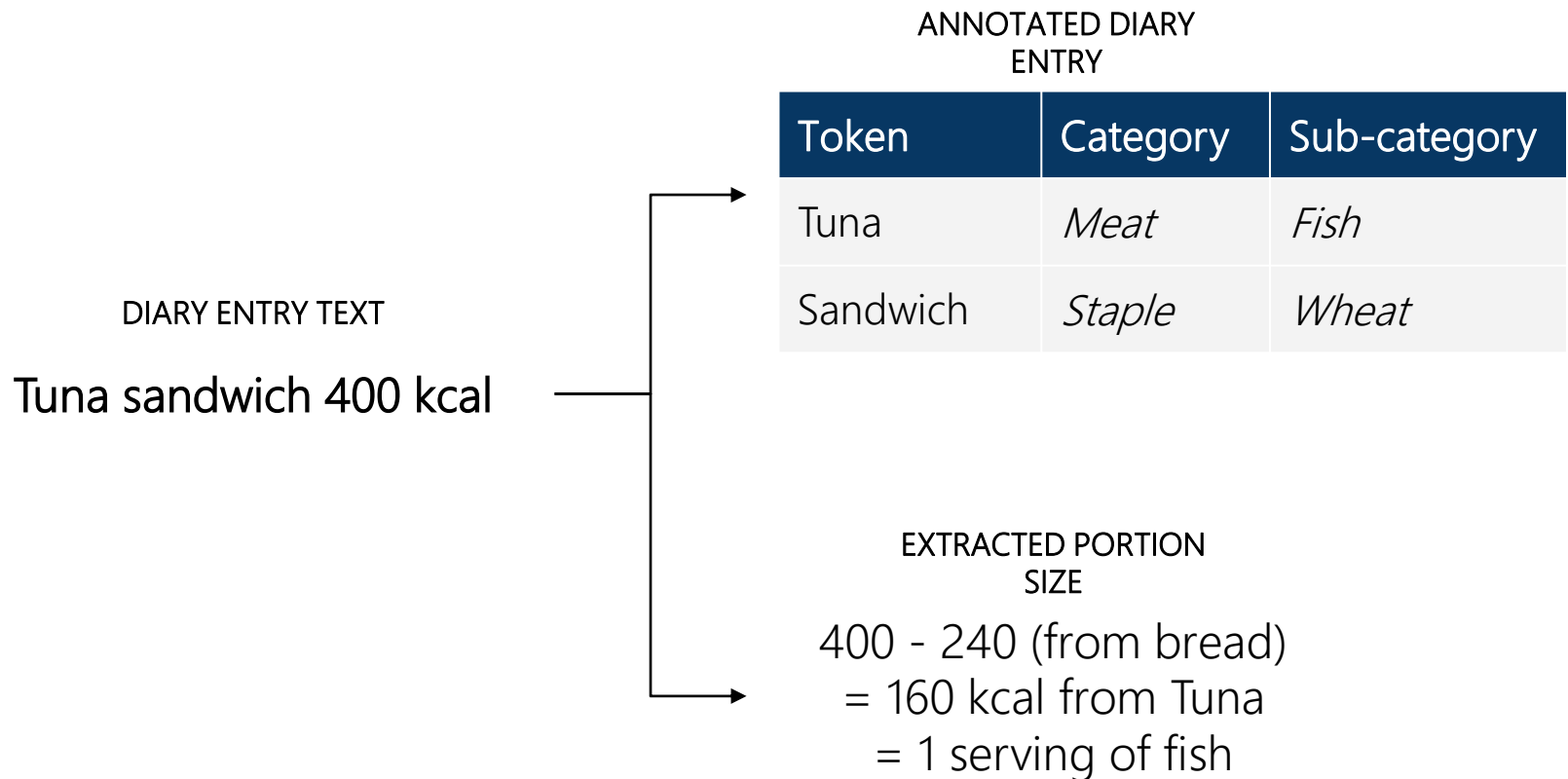
8.8K
MFP Users

6.3K
Active MFP Users

RQ 2

Post-Processed Data

Standardized units: portion size (serving) or milli-liter (ml)



RQ1: Do active food journalers have healthier eating behaviors than the general populace?



Fruits & vegetables








Animal-based protein sources








Added sugar

Public Dietary Intake From Previous Studies

CATEGORY		DAILY RECOMMENDED INTAKE	PUBLIC DIETARY INTAKE	INTAKE PATTERNS
	Fruits & vegetables (FV)	≥ 5 serv	3.2 serv	Less than 15% of people eat enough FV.
	Red & processed meat	≤ 1 serv	2.3 serv	Red & processed meat accounts for more than 50% of meat consumed in the US.
	Fish	≥ 0.29 serv	0.17 serv	Low consumption in the US.
	Added sugar	≤ 25 g	70 g	36% of added sugar intake are from sugary drinks.
	Sugary drink	≤ 237 ml	≤ 237 ml	48% of Americans drink at least 1 glass of soft drink on an average day.

Journaler Dietary Intake

CATEGORY	DAILY RECOMMENDED INTAKE	PUBLIC DIETARY INTAKE	JOURNALER DIETARY INTAKE	INTAKE PATTERNS
 Fruits & vegetables (FV)	≥ 5 serv	3.2 serv	1.97 serv	Less than 1% of journalers meet the recommendation at least 80% of the time.
 Red & processed meat	≤ 1 serv	2.3 serv	0.53 serv	Low red & processed meat intake, high poultry intake.
 Fish	≥ 0.29 serv	0.17 serv	0.09 serv	15% of journalers meet the recommendation.
 Added sugar	≤ 25 g	70 g	16 g	The top-25% of journalers consume 29.83 grams on average.
 Sugary drink	≤ 237 ml	≤ 237 ml	≤ 237 ml	46.75% of journalers drink at least 1 glass of soft drink on an average day.

Overall Findings



Healthy eating behaviors of active food journalers do not differ much from those of the general populace in several areas

The numbers of healthy eating lapses observed are quite surprising given that our population is highly skewed toward females, who tend to be health-conscious.

RQ2: How do food journalers behave significantly differ across sociodemographic groups?

SOCIODEMOGRAPHIC GROUPS

According to MFP profile information.



GENDER

Female (82%)
Male



AGE GROUP

18 - 44 (79.8%)
45+



SOCIAL

Q1 (0-6) (30.49%)
Q2 (7-18)
Q3 (19-41)
Q4 (42+)



REGIONS

US (70.88%)
Non-US

South (33.76%)
Midwest
West
Northeast

Behavioral Measures: Journaling & Healthy Eating



Recording days



Lapsing frequency (% of total days)



Caloric intake



FV intake/frequency



Red & processed meat intake/frequency



Fish intake/frequency















Added sugar intake/frequency



Sugary drink intake/frequency

Hypothesis testing
performed by Mann-
Whitney U and Kruskal-
Wall H tests.






































Results

					
CATEGORY OF BEHAVIORS		GENDER	AGE GROUP	SOCIAL	REGION
	Recording days	Male	45+	Q4	Northeast
	Lapsing frequency	Female	18-44	Q1	-
	Caloric intake	Male	18-44	Q4	-
	FV intake/frequency	Male/Female	-/-	Q4/Q4	West/West
	Red & processed meat intake/frequency	Male/Male	45+/45+	-/Q4	Midwest/Midwest
	Fish intake/frequency	-/Male	-/45+	-/-	/-
	Added sugar intake/frequency	-/Female	18-44/18-44	Q1/Q1	-/-
	Sugary drink intake/frequency	-/Female	-/18-44	-/Q1	-/-

Overall Findings

- Food journalers who are male, 45 years or older, and have the largest social network tend to have significantly longer journaling duration and more persistent in recording food journals**
- The healthy eating behaviors of food journalers within the sociodemographic groups are not as homogeneous as we initially expected.**

Top Predictors of Eating Behaviors

PREDICTED VARIABLE		TOP-3 PREDICTORS	LEAST IMPORTANT PREDICTOR	ADJUSTED R ²
	Recording days	  		0.055
	Lapsing frequency	  		0.026
	Caloric intake	  		0.219
	FV intake	  		0.012
	Red & processed meat intake	  		0.04
	Fish intake	 		0.011
	Added sugar intake	  		0.028
	Sugary drink intake			0.02
	Lapsing frequency			Age

Summary of This Study

Journaling benefit may be more about
mindful to eat less...

...and less about mindful to eat
healthy!



National Day Rally 2017: Singapore's War on Diabetes

The Fight Against Diabetes: A Worrying Trend



Today,
1 in 3
aged 65 and above
has diabetes¹

There is a
1 in 3 chance
you will get diabetes
in your lifetime²



www.moh.gov.sg/budget2016

*"Four simple ways to fight diabetes: Go for regular medical check-ups; Exercise more; **Watch your diet**; and Cut down on soft drinks."*

- PM Lee Hsien Loong



Traditional Food Journal



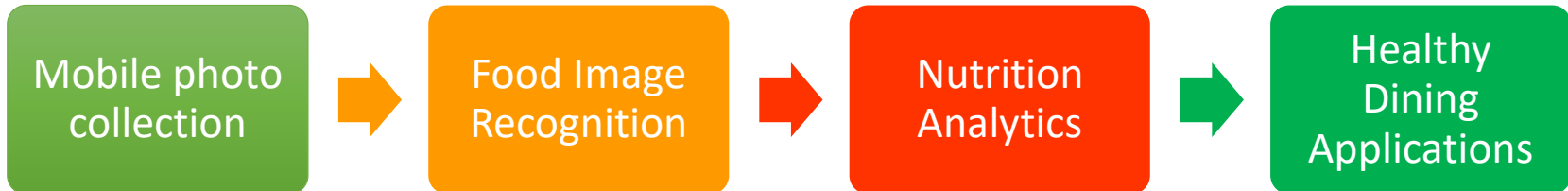
https://www.womenshealthmag.com/sites/womenshealthmag.com/files/images/food-journal-1_0.jpg

✗ Tedious

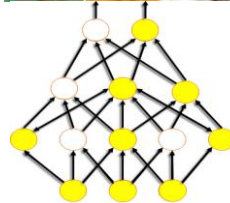
✗ Non-efficient

✗ Non-effective

FoodAI for Smart Food Logging



Healthy 365



FOODAI

Nutrition Facts	
Serving Size 172 g	
Amount Per Serving	
Calories 200	Calories from Fat 8
% Daily Value*	
Total Fat 1g	1%
Saturated Fat 0g	1%
Trans Fat	
Cholesterol 0mg	0%
Sodium 7mg	0%
Total Carbohydrate 36g	12%
Dietary Fiber 11g	45%
Sugars 6g	
Protein 13g	
Vitamin A 1%	Vitamin C 1%
Calcium 4%	Iron 24%
*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.	
NutritionData.com	



Challenges (Specific to Food Paradise)

Many food choices

- Singapore's food choices:
1038 food items
158 food categories

Different names for the same food

Many foods look alike

Examples of Look-alike Foods



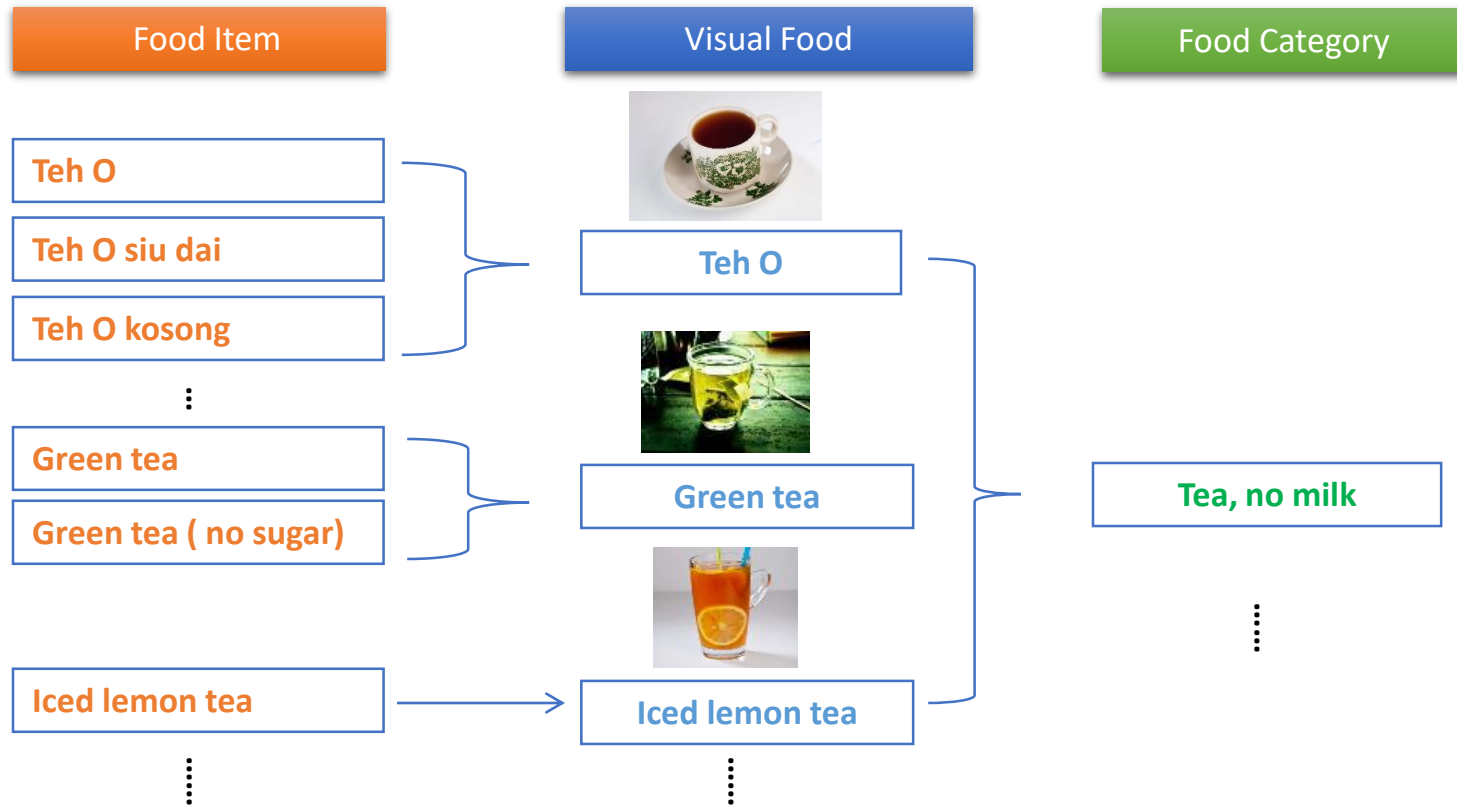
<http://supermerlion.com/wp-content/uploads/2010/04/madnesskopiteh.jpg>

Singapore Tea or Teh

- *Teh*, tea with milk and sugar
- *Teh-C*, tea with evaporated milk
- *Teh-C-kosong*, tea with evaporated milk and no sugar
- *Teh-O*, tea with sugar only
- *Teh-O-kosong*, plain tea without milk or sugar
- *Teh tarik*, the Malay tea
- *Teh-halia*, tea with ginger water
- *Teh-bing*, tea with ice, aka *Teh-ice*
- *Teh-siu-dai*, tea with less sugar
- *Teh-gah-dai*, tea with extra sweetened milk

.....

Food Name Hierarchy



FoodAI: A Deep Learning Approach

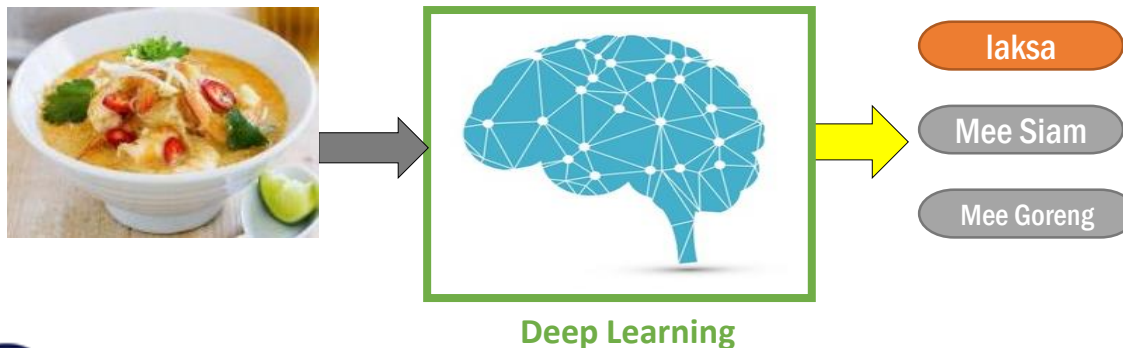
Traditional Approach



• Pros and Cons

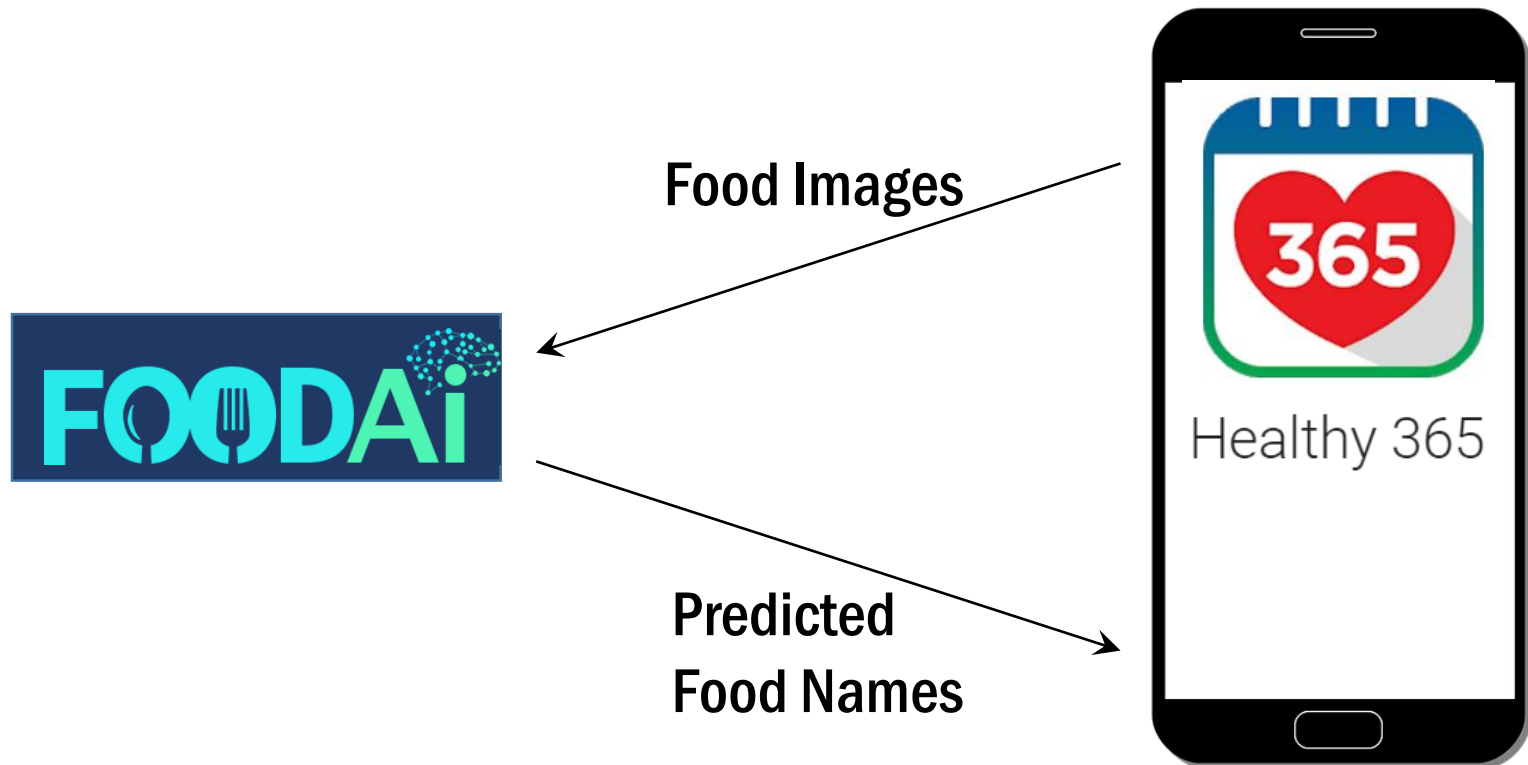
- Requires domain experts
- Time consuming
- Error prone
- Not very accurate

Deep Learning Approach



- ✓ Learn from data automatically
- ✓ Easily to extend
- ✓ More data more accurate
- ✓ Speedup with HPC/GPUs

FoodAI used in Food Journaling App



Example 1



Foodai.org



Chilli Crab



Black Pepper Crab



Fish Head Curry



Chicken Curry



Assam Pedas



Example 2



Foodai.org



Satay

Lontong

Tandoori

Chai Tow Kway

Rojak

Example 3



Foodai.org



Youtiao



Keropok



Hum Chim Peng



Pineapple



Tau suan



FoodAI: Open API Services for Developers

[Home](#)[About](#)[Demo](#)[Developer](#)[Contact](#)[Log in](#)

<http://www.foodai.org>



Smart Food Recognition with the state-of-the-art Visual Recognition technology

Try our Demo

FOODAI™ Demo

Try out our demo below or visit our developer portal for our API services.



Chilli Crab

Black Pepper Crab

Unknown

Tandoori

Assam Pedas

Choose a file

<http://sites.psu.edu/thingo/wp-content/uploads/sites/40642/2016/02/Chilli-Crab1.jpg>

Go!



Healthy 365

Concluding Remarks

Data Science for learning people behavioral insights

- Healthy Eating and Job Hopping

Data Science for helping people track their activities, adjust and adapt to changes around them

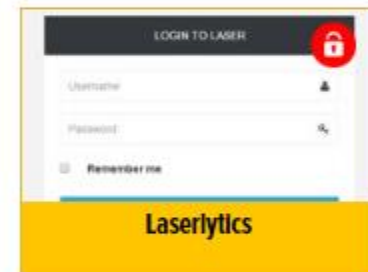
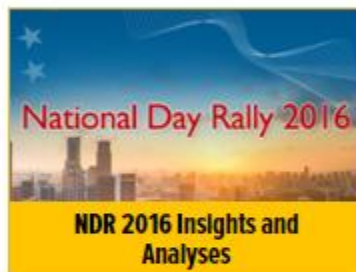
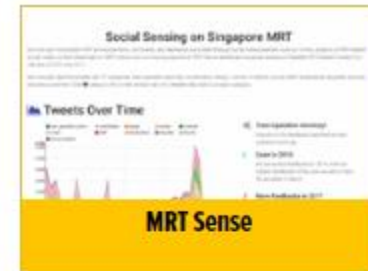
Data Science can be challenging due to complex data issues:

- Data availability
- Data noise
- Data bias

Data science for real world applications

Other Projects in LARC

<http://larc.smu.edu.sg>



Thank you

We are hiring research scientists, research fellows and engineers

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