USE OF ARTIFICIAL INTELLIGENCE IN OPTIMIZING NUTRITION

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Market is flooded with nutrition/diet apps
APPS TEST-BED SAYS...

... these are not apps, but are traps
Apps Test-Bed (Cont.)

- Does these diet apps do any good?
- Are they modelling nutrition all right?
- How much of the biological (nutritional) knowledge is taken into consideration while designing this apps?
- What is the role of AI in nutrition?
- Is it all feasible or are their any known limitations?
CONTENT

› History of optimizing nutrition
› Expert systems
› Marriage of science and AI
› Big-data analytics in nutrition
› Conclusions
Ayurvedic diet prescriptions ~3000 years ago in India

Ayurvedic diet incorporates nearly all the natural ingredients that have the positive influence throughout the body.
Menu planning with a computer

The general objectives of the menu planning are recognized as achieving:

1. palatable,  
2. nutritionally balanced and  
3. economical diet

Linear programming method:  
has an objective function and constrains and a feasible solution need to be obtained

Until the 1990s, computer-assisted menu planning were not widely used. Human experts consistently outperform computers.

The general objectives of the menu planning are recognized as achieving:

1. palatable,
2. nutritionally balanced and
3. economical

Other methods:

1. Evolutionary computation (Genetic algorithms)
2. Collective intelligence (e.g. Bacterial foraging)
Expert system: AI system that attempts to model the processes of an human expert

Methods for inference were majorly:
1. Cases based reasoning
2. Rule based reasoning

Novelty: Incorporation of expert knowledge
Knowledge:
1. Database of foods
2. Case base of menus (dietary guidelines)
3. Nutritional risk indicators

Clinical measurement data + Physiology

| The anthropometry data | • Calculation of obesity  
| | • BMI  
| | • Waist/hip ratio  
| | • Kaup index  
| The computation of calorie expenditure | • Basal metabolic expenditure  
| | • Specific dynamic action  
| | • Total calorie expenditure  
| The state of eating habits | • The analysis of eating habits  
| | • Eating habits for hyperlipidemia  
| | • Convenient method for analysis of nutrients  
| Nutrition prescription | • Prescription of each test  
| | • Synthetic prescription by experts  
| The computation of calorie expenditure | • CAGE  
| | • NAST  
| | • AUDIT-K  

Diet advice based on health state and health goals were added
**HISTORY ~ 1990 – 2000 AND BIT BEYOND...**

A typical outcome from an expert system

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### CAMP's Recommended Menu

**Breakfast**
- ½ c pineapple chunks, packed in juice
- 2 English muffins with 2 tsp margarine
- 1 c skim milk

**Lunch**
- Sandwich
  - 1 slice whole wheat bread
  - 2 oz chicken breast
  - 1 leaf lettuce
  - 1 slice tomato
  - 1 tsp mayonnaise type salad dressing
  - 1 c vegetable soup
  - 6 saltine crackers
  - 1 ½ medium oranges
  - 1 c skim milk

**Dinner**
- Salad
  - 1 c mixed salad greens
  - ½ medium tomato, sliced
  - 1 tbsp Italian dressing
  - 3 oz roast leg of lamb
  - ½ c spinach
  - 1 medium baked potato
  - 1 tsp margarine
  - ½ c corn
  - Coffee, tea, or water

**Snack 1**
- ½ c raisins

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### Nutritional Profile

**Energy:** 1,830 kcal

- Percentage of energy from fat: 23
- Percentage of energy from protein: 19
- Percentage of energy from carbohydrate: 61
- Percentage of energy from alcohol: 0

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### Percentages of Reference Daily Intakes (RDI)*

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Protein: 173%</th>
<th>Niacin: 137%</th>
<th>Vitamin B-12: 71%</th>
<th>Vitamin E: 30%</th>
<th>Phosphorus: 140%</th>
<th>Copper: 102%</th>
<th>Vitamin C: 333%</th>
<th>Folic acid: 146%</th>
<th>Iron: 108%</th>
<th>Potassium: 132%</th>
<th>Zinc: 72%</th>
<th>Thiamin: 134%</th>
<th>Vitamin B-6: 124%</th>
<th>Vitamin A: 369%</th>
<th>Calcium: 123%</th>
<th>Magnesium: 113%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intakes (RDIs)*</td>
<td>Protein: 5.5 g</td>
<td>Alcohol: 0.0 g</td>
<td>Vitamin C: 199.60 mg</td>
<td>Folic acid: 2.29 mg</td>
<td>Iron: 19.44 mg</td>
<td>Copper: 2.03 mg</td>
<td>Protein: 86.3 g</td>
<td>Alcohol: 0.0 g</td>
<td>Vitamin B-6: 2.471 mg</td>
<td>Vitamin A: 3.455 IU</td>
<td>Calcium: 1.209 mg</td>
<td>Potassium: 4.617 mg</td>
<td>Zinc: 10.86 mg</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**FIG 4.** The Case-based Menu Planner's menu and analysis for the input shown in Figure 3.

*The standard method of calculation does not ensure that percentages add to 100.

*The RDI for Vitamin B-12 is 6 μg, which is higher than other standards. See reference 13.
LIMITATIONS OF EXPERT SYSTEM

Case based reasoning

Rule based reasoning

Not suitable for personal dietary advice

Adapted from Rajagopal, Diss. University of Washington, 2007.
MARRIAGE OF SCIENCE AND AI

› How much of the biological (nutritional) knowledge is taken into consideration while designing this apps?
› What is the role of AI in nutrition?

Drivers for success; Science; AI; Marriage of science and AI
People eating identical meals present high variability in post-meal blood glucose response.

Diet dominates host genotype in shaping the murine gut microbiota.

HFHS: high-fat, high-sugar diet
LFPP: low-fat, high-plant-polysaccharide diet
AI (1)

“Educating the mind without educating the heart is no education at all.”

Aristotle

Syllogism → deductive reasoning or inference

- First order logic: resulted in several AI languages. e.g. PROLOG
- Key: mathematically expressed

Very successful: e.g. building expert systems

→ Artificial Neural network (mimic the working of the brain)
→ Driven by data

Least successful and enthusiasm over neural net came down around 1970
Today’s algorithms crunch voluminous data and discover patterns, relationships among data variables…...teach themselves too.

After a silence, interest in Artificial Neural Network (ANN) sparked again

Hidden layers is greater than 2 then Deep learning architecture
MARRIAGE OF SCIENCE AND AI

Rationally designed personalized dietary approaches determine the effects of numerous parameters on diet response (e.g. microbiome composition, genome variability, personal lifestyle, medical metadata). Machine learning algorithms utilize these comprehensive data sets to deliver dietary recommendations.

Precision nutrition aims to **prevent and manage chronic diseases by tailoring dietary interventions** or recommendations to one or a combination of an individual’s genetic background, metabolic profile, and environmental exposures.

WORD OF CAUTION

Several commercial companies have started to **market personalised nutrition assessment and treatment based on genotypes**, but the benefits of such approaches on improving diet quality and health outcomes have not been demonstrated.

Personal nutrition is part of a personal health package.
AT TNO (CONT.)

I make regular adjustments to my diet and behavior in order to stay on track

Can we make use of thousands of other personal health timelines to optimize every decision I make for my personal health?

Bayesian networks
Artificial Intelligence
So how does personalized nutrition work?

1. It is personal
2. The intervention or advice is based on a diagnosis
3. A (science based) model is used to translate diagnosis into advice
4. The model is tailored to specific conditions and goals from a large toolbox
5. The toolbox is continuously and systematically updated with all relevant scientific knowledge
6. Exploit/use information from large numbers of personal health data
MAJOR CONCLUSIONS

› AI assist in increasing and applying our current knowledge in science
› Science based models augmented with the number crunching power of AI must drive nutritional research (health advice: dietary)

› Precision medicine is to become a reality soon (AI on a chip is available today)
THANK YOU FOR YOUR ATTENTION