Human dietitians vs. Artificial intelligence: Which diet design do you prefer for your children?

Changhun Lee[1*], Soohyeok Kim[1*], Jayun Kim[2], Chiehyeon Lim, PhD[1,3], Minyoung Jung, MD, PhD[4]

[1]Department of Industrial Engineering, Ulsan National Institute of Science and Technology (UNIST), Ulsan, Korea; [2]Kosin Innovative Smart Healthcare Research Center, Kosin University Gaspel Hospital, Busan, Korea; [3]Graduate School of Artificial Intelligence, UNIST, Ulsan, Korea; [4]Department of Pediatrics, Kosin University College of Medicine, Kosin University Gospel Hospital, Busan, Korea

Background

Caregivers of children with food allergy should always be concerned about the diet design to ensure adequate intake of nutrients and elimination of implicated foods. However, it is difficult to design a customized diet for children, given the high level of required knowledge on nutrients and growth. Artificial intelligence (AI) can provide a solution for the diet design job for children as it can apply the professional knowledge automatically and address the complexity of optimal diet design efficiently. We developed two AI solutions for children and evaluated the utility of AI-generated diets system.

Methods

1. Menu generation AI

1-1. Data

Food data consists of nutrition parts, ingredients parts and group column. The nutrient part indicates the nutrients included in the standard serving of each food. The diet dataset is a standard public diet from the Center for Children's Food Service Management located in a city of South Korea. This center is established by the Ministry of Food and Drug Safety to support hygiene and nutrition management for daycare centers and kindergartens.

1-2. Generative Adversarial Nets (GAN)

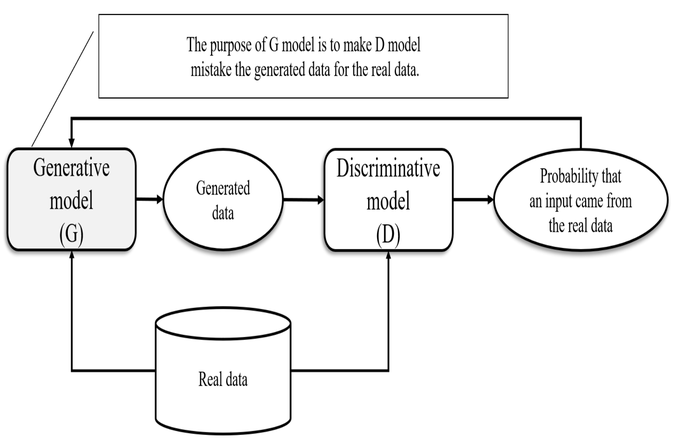


Figure 1: The framework of Generative Adversarial Nets

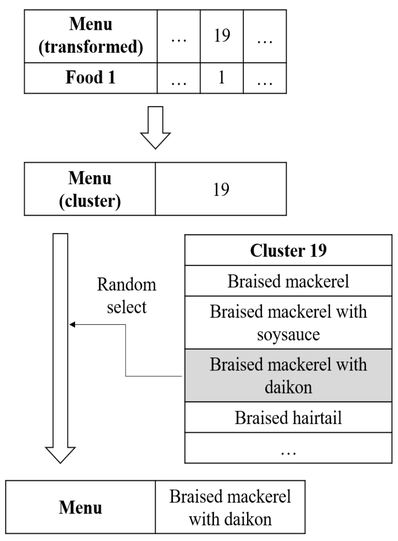
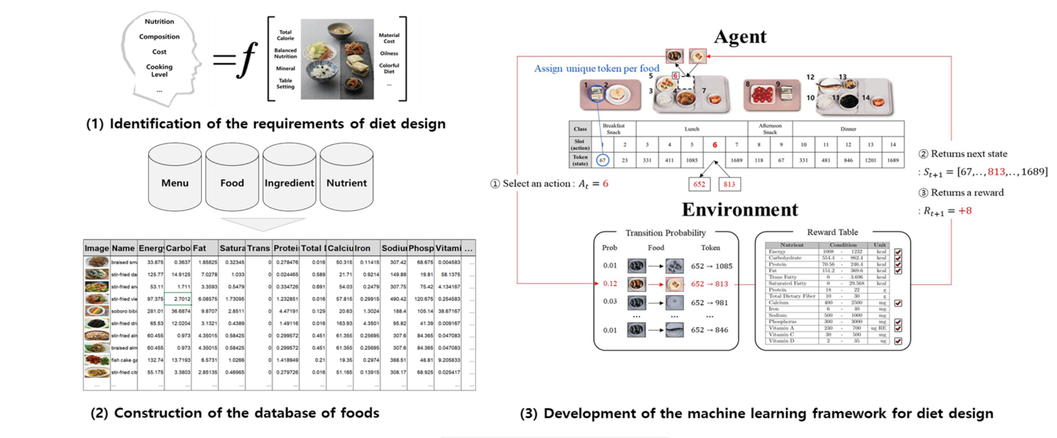


Figure 2: Menu data transform process

1-3. Reinforcement Learning (RL)



Class	Breakfast Snack		Lunch		…	Afternoon Snack		Dinner		…	Nutrient Condition		…	
Dish	Morning 1	Morning 2	Lunch 1	Lunch 2	…	Afternoon 1	Afternoon 2	Dinenr 1	Dinner 2	…	Condition 1	Condition 2	…	Condition n
Slot	0	1	2	3	…	7	8	9	10	…	Macronutrient Ratio	Total Calorie	…	Vitamin D
Diet	strawberry	soymilk	steamed rice	potato vegeta	…	vegetable rice	cocoa	multigrain rice	fish cake soup	…	Achieved !	Achieved !	…	Achieved !
	banana	soymilk	hayashi rice w	yubu shrimp	…	steamed swee	grape juice	omlet rice	seaweed past	…	Achieved !	Achieved !	…	Achieved !
	pear	soymilk	vegetable frie	zuccini tofu s	…	bibim noodle	barley tea	multigrain rice	squid stew	…	Achieved !	Achieved !	…	Achieved !
	soft tofu/mari	soymilk	mushroom ric	cabbage soup	…	sweet red-bea	citron tea	chinese shrim	siraegi soup v	…	Achieved !	Achieved !	…	Achieved !
	shrimp salted	soymilk	hayashi rice	assorted fish	…	fish cake sou	orange juice	multigrain rice	cheonggukjan	…	Achieved !	Achieved !	…	Achieved !
	…	…	…	…	…	…	…	…	…	…	Achieved !	Achieved !	…	Achieved !

(4) Automatic generation of the diets that satisfy the requirements of composition, nutrition, and others

Figure 3: the development process of the RL-based AI solution

2. Survey information

We conducted the two surveys: In the first survey, 41 people participated. Here, 38 subjects revealed their careers, 24 nutritionists, 9 day-care teachers and 5 pediatricians. In the second survey, 27 of the participants in the first survey participated.

	Food 1	Food 2	Food 3	Food 4	Food 5
Morning snack	Carrot stick	Milk			
Lunch	Jajang Rice Bowl	Miso soup	Fried dumplings	Kimchi	
Afternoon snack	Chicken noodle soup				
Dinner	Rice	Fish cake soup	Boiled pork	Cucumber Na-mool	Kimchi

Item	Question
Adequacy of nutrients	**Does the configured diet meet nutritional standards?**
	Is the carbohydrate, protein and fat ratio appropriate?
	Is the use of frozen and finished products appropriate?
Foods composition style	**Are various recipes used within the one-day menu?**
	Is avoid duplicate use of the same ingredients?
	Is the composition of the snack appropriate?
	Are various food groups used evenly for nutritional intake balance?
Comprehensive evaluation	**Overall, do you think this diet is appropriate for infants aged 3 to 5?**

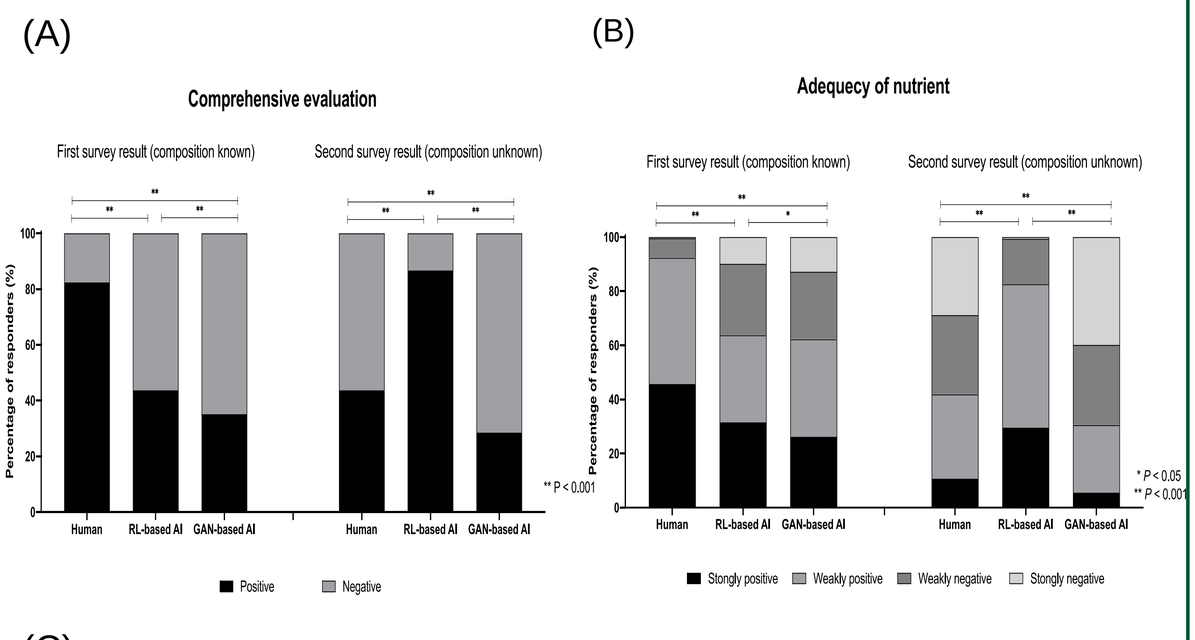
Table 1. An example of first survey. We randomly mixed each of the 15 diets created by GAN, RL, and nutritionist and asked questions for each diet.

	Morning snack	Lunch	Afternoon snack	Dinner	Sum
Energy (kcal)	268.54	339.1	177.66	391.28	1176.58
Carbohydrate (g)	24.929	59.604	41.374	46.978	172.885
Protein (g)	13.003	3.62	0.281	6.929	23.833
Fat (g)	8.981	5.861	2.546	11.94	29.328
Trans Fatty (g)	4.698	1.257	0.346	2.463	8.764
Saturated Fatty (g)	0	0	0	0	0
Total Dietary Fiber (g)	0	2.325	6.942	0.777	10.044
Calcium (mg)	259.96	101.51	15.98	153.31	530.76
Iron (mg)	0.57	3.026	0.37	2.333	6.299
Sodium (mg)	207.02	313.62	68.46	347.03	936.13
Phosphorus (mg)	236.88	174.21	36.57	310.5	758.16
Vitamin A (μg RE)	110.118	172.063	40.83	90.714	413.725
Vitamin C (mg)	1.58	12.978	5.416	31.604	51.578

Item	Question
Adequacy of nutrients	**Does the configured diet meet nutritional standards?**
	Is the carbohydrate, protein and fat ratio appropriate?
Comprehensive evaluation	**Overall, do you think this diet is appropriate for infants aged 3 to 5?**

Table 2. An example of second survey. The same menu of the first survey was evaluated, but only nutrient information was provided instead of each food in the diets.

Results



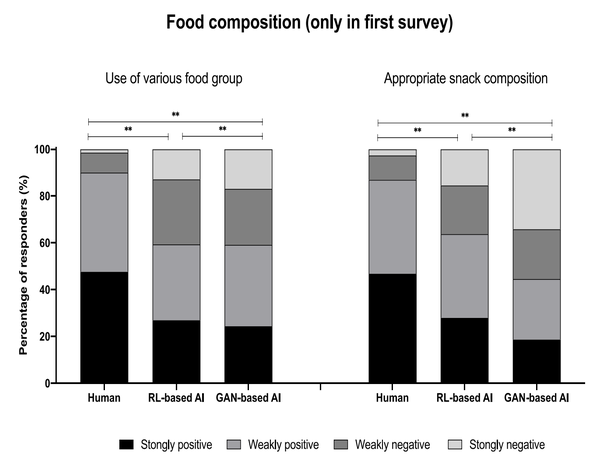


Figure 4. The proportion of response to evaluate diets from human, RL and GAN by experts. Both providing diets were same, but results were different between first and second survey. (A) In the first survey, the proportion of positive response to overall evaluation in human-made were higher than RL and GAN-made diets. However, in the second surveys, the proportion of positive response in the RL-made diets was higher than the human and GAN-made diets. (B) In the first survey, the proportion of strong positive response in adequacy of nutrition was 45.7%, 31.5% and 26.2% for the human, RL and GAN-made diets, respectively. However, subjects evaluated the RL-made diets more strongly positive in nutrition adequacy than the human and GAN-made diets in the second survey. (C) When evaluating the composition style of diet, subjects responded more strongly positively to the human-made diets than the RL and GAN-made diets

Conclusions

This is the first study showing the development and evaluation of AI for diet design for children. This study shows the possibility and direction of developing a dietary AI for children with food allergies. We conclude that both composition and nutrients satisfaction should be considered in developing a diet design AI for children. Our next aim is to improve the composition satisfaction capability of our RL-based AI solution, beyond the nutrients satisfaction.

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