

: Dataset creation using combinatorial optimization and controllable generation with domain experts

Concept of Diet problem

- Diet problem is one of the optimization studies first presented in the 1930s and 1940s, for the purpose of feeding a healthy diet to the soldiers with minimal cost.
- The goal of the diet problem is to select a set of foods that achieve the nutritional level of recommended daily Intake (RDI).
- In diet problem, a diet is the serving of meals (e.g., breakfast, lunch, dinner, snack) and consists of foods that represent the served dishes.
- RDI is an estimate that meets the nutrient needs of nearly all (97-98%) healthy populations by sex and age, equal to the average need plus twice the standard deviation.



	Age 2- Years
Calcium (mg)	500
Protein (g)	13
Vitamin D ^a (IU)	400

Previous Approaches and Limitations

- The diet problem is defined as a decision problem
- A classical approach to the diet problem was to set the decision problem as a continuous optimization problem and apply linear programming (LP) since the decision variables are the quantity (i.e., grams) of each food which ranges on real-valued area and the objective function is (usually) to minimize the total cost of the foods subject to the constraints such as RDI.
- Diet planning problem extends the boundary of decision variable from per-food quantity to the combination and quantity of foods, setting a decision problem as a combinatorial optimization problem, and applying mixed-integer programming (MIP).
 - MIP can consider both real-valued (gram; quantity) and integer-valued (0/1 binary; combination) decision variables.



	Table 5: Comparison between real diet and generated diets									
	(Source Diet)	(Translated Diet)								
10	Real	TFR	SCST	MIXER						
°1	s_strawberry	s_strawberry	s_watermelon	s_nuts						
°2	s_milk (200ml)	s_milk (200ml)	s_milk (100ml)	s_milk (200ml)						
3	steamed millet rice	steamed white rice	s_milk (100ml)	steamed millet rice						
	acorn jelly soup	dried pollack soup	braised tofu	tofu soy paste soup						
4		uneu ponaek soup	in marinade sauce							
¢5	rolled omelette with cheese	rolled omelette with cheese	s_watermelon	rolled omelette with cheese						
~	seasoned salad with	seasoned salad with	cabbage soy paste soup	seasoned salad with						
-6	napa cabbage in soy paste	napa cabbage in soy paste	cabbage soy paste soup	napa cabbage in soy paste						
°7	radish kimchi cubes	radish kimchi cubes	radish kimchi cubes	radish kimchi cubes						
C 0	s_soboro bun	s steamed sweet potato	s watermalon	s_fermented rice cake						
-8	(streusel-like cursted bread)	s_steamed sweet potato	s_watermeion							
(9	s_barley tea	s_barley tea	s_milk (100ml)	s_barley tea						
c ₁₀	steamed white rice	steamed millet rice	steamed sweet brown rice	steamed black rice						
c ₁₁	dried pollack soup	shepherd's purse soy paste soup	cabbage soy paste soup	tofu soup						
~	stir-fried chicken	stir-fried chicken	braised tofu	braised chicken						
12	in soy sauce	in soy sauce	in marinade sauce	in teriyaki sauce						
c ₁₃	cucumber salad	cucumber salad	s_watermelon	dried mussel seaweed soup						
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	real diets 11.63		OR 15.00 0.43 6.32		Expert 12.26 0.06 5.70		ML 13.19 0.05 3.61	
RDI score (\uparrow) % Mispos (\downarrow) \mathcal{X}^2 (\downarrow)								
Energy Protein % Carbo % Protein % Fat Dietary Fiber Calcium Iron Sodium Vitamin A Vitamin B1 Vitamin B2 Vitamin C Linolenic α-Linoleic	$\begin{array}{c} 1359.5\\ 56.16\\ 0.61\\ 0.17\\ 0.21\\ 9.84\\ 592.6\\ 9.26\\ 1978.5\\ 445.3\\ 1.15\\ 1.32\\ 56.9\\ 6210.9\\ 886.2 \end{array}$	(68%) (100%) (87%) (100%) (97%) (21%) (97%) (100%) (11%) (87%) (100%) (100%) (100%) (69%) (82%) (44%)	$\begin{array}{c} 1383.5\\ 53.45\\ 0.62\\ 0.15\\ 0.22\\ 17.52\\ 612.3\\ 10.74\\ 1517.4\\ 345.7\\ 0.97\\ 1.29\\ 55.56\\ 7407.3\\ 869.3 \end{array}$	$\begin{array}{c} (100\%)\\$	$\begin{array}{c} 1314.4\\ 54.72\\ 0.61\\ 0.17\\ 0.22\\ 12.92\\ 538.8\\ 9.47\\ 1663.7\\ 349.7\\ 0.96\\ 1.19\\ 61.28\\ 6965.5\\ 938.0 \end{array}$	$\begin{array}{c} (62\%)\\ (100\%)\\ (77\%)\\ (98\%)\\ (94\%)\\ (74\%)\\ (57\%)\\ (100\%)\\ (44\%)\\ (88\%)\\ (100\%)\\ (100\%)\\ (100\%)\\ (87\%)\\ (82\%)\\ (61\%) \end{array}$	$\begin{array}{c} 1321.97\\ 55.66\\ 0.61\\ 0.17\\ 0.22\\ 13.08\\ 601.25\\ 9.78\\ 1620.81\\ 374.93\\ 0.94\\ 1.27\\ 71.93\\ 6796.78\\ 925.70\end{array}$	(72%) (100% (81%) (100% (98%) (73%) (94%) (94%) (100% (100% (78%) (100% (53%) (90%) (73%)
Time required $\#$ of diets	$\begin{vmatrix} & -\\ & 62 \end{vmatrix}$		$\begin{array}{c} 30 \ \mathrm{min} \\ 500 \end{array}$		$3 \text{ weeks} \leq 500$		40 hours 500	

Table 1: Evaluation results of the diet data generated by the ORxML framework



Table 4: Result of survey									
	Score of the evaluation criteria								
Questions	1.1	1.2	1.3	2.1	2.2	2.3	2.4	3.1	3.2
$egin{array}{c} Real \\ OR \\ Expert \\ ML \end{array}$	$\begin{array}{c c} 4.38 \\ 3.75 \\ 4.30 \\ 4.26 \end{array}$	$\begin{array}{c} 4.15 \\ 3.12 \\ 4.01 \\ 3.92 \end{array}$	$3.97 \\ 3.52 \\ 4.03 \\ 3.80$	$3.96 \\ 3.25 \\ 4.04 \\ 3.80$	$3.87 \\ 2.56 \\ 3.81 \\ 3.61$	$3.85 \\ 3.17 \\ 3.93 \\ 3.82$	$3.70 \\ 2.38 \\ 3.83 \\ 3.39$	$3.62 \\ 2.19 \\ 3.61 \\ 3.29$	$0.67 \\ 0.15 \\ 0.68 \\ 0.55$



