Mobile App User Choice Engineering using Behavioral Science models

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Setting

- When interacting with mobile apps, users need to make a choice out of a set of alternatives offered by the app
- Goal: Nudge users towards decisions that are best for them and for the app platform
- Examples:

Application domain	Instance	Platform optimization objective
Mobile crowdsensing	App assigns crowdsensing tasks to users	Maximize quality of fulfilled tasks
Smart Energy apps	App issues energy-saving recommendations	Maximize amount of energy savings
Mobile advertising	App displays ads or offer coupons to users	Maximize revenue through user response to ads

Challenges

- **How to model user choice-making**
- Users do not decide rationally, have to make a choice quickly while interacting with mobile app
- **How to Incorporate choices in platform optimization objective**
- Need to appropriately engineer user incentives

Idea

- Model user choice-making through concepts from Behavioral Science
  - class of Fast-and-Frugal-Tree (FFT) Lexicographic heuristics
- Use incentives as one of the features that determine **user choice** (to a different extent for different users) and **allocate** them so as to achieve platform optimization objective

Model

- Set of features $\mathcal{F}$ that determine user choices
- $\mathcal{F}$ = {distance (effort) to do a task (d), incentive (p)}
- Mobile app issues pairs of recommendations (choices) to each user u
- Example message e.g. in a mobile crowdsensing app

Choice A: "Go to place A at distance d_A to do a task for payment p_A" OR
Choice B: "Go to place B at distance d_B to do a task for payment p_B"

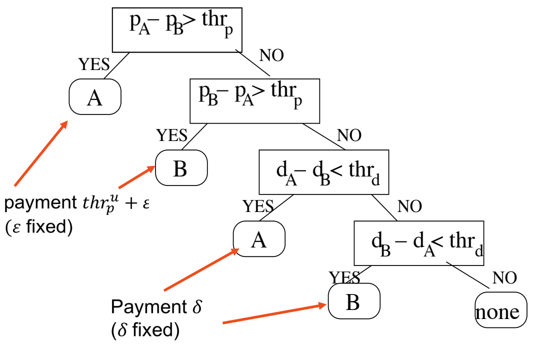
Deterministic user decision model

- A certain **order** in which to consider features of alternative choices A, B offered (e.g. first p then d - or vice versa)
- If choice A (B) is "clearly better" than the other, B (A) w.r.t. 1st feature in order, select A (B);
- Else consider 2nd feature
- If choice A (B) is "clearly better" than the other, B (A) w.r.t. 2nd feature In order, select A (B);
- If no choice is "clearly better than the other, select none of the choices
- **Thresholds** thr_p^u, thr_d^u determine when a choice is "clearly better" than the other in terms of a feature (p or d)

User model training

- Find feature order for each user
- Compute decision thresholds for each user

Users prioritizing payment (p) over distance (d) decide according to tree below



Users prioritizing distance (d) over payment (p) decide according to a tree that first considers distance, then payment

Problem Statement

Given:

- set of N users $\mathcal{U}$, each modeled by a decision tree
- set of tasks $\mathcal{C}$
- set of available pairs of choices $\mathcal{P} \subseteq \mathcal{C} \times \mathcal{C}$ for assignment
- limited budget b_i for each task i
- a quality index q_i^u for user u and task i

Allocate pairs of choices and payments to users so as to maximize total expected quality of fulfilled tasks (here: allocate 1 pair of choices)

Decision variables for each user u

- Choice pair (i,j) offer variable $y_{(i,j)}^u \in \{0,1\}$
- Variables $z_i^u \in \{0,1\}$; determine whether to make a choice i "clearly better" than the other
- Even for fixed variables $\boldsymbol{z}$, problem is Generalized Assignment Problem (GAP); NP-Hard

Numerical Results

- Synthetic dataset; performance metric: total quality
- Heuristics for budget and task assignment

	Recommend closest task	Recommend task to most skilled user
Split task budget equally	CLOSE-EQ	SKILL-EQ
Split task budget in proportion to user skills	CLOSE-PROP	SKILL-PROP

	GAP	CLOSE-EQ	CLOSE-PROP	SKILL-EQ	SKILL-PROP
N=200, $b_i \sim \mathcal{U}[10,20]$	172.67± 2.2	85.03± 7.3	88.24± 6.5	100.26± 6.37	111.64± 4.17
N=100, $b_i \sim \mathcal{U}[10,20]$	87± 1.55	47.9± 3.18	47.39± 2.76	59.47± 3.07	59.93± 2.97
N=200, $b_i \sim \mathcal{U}[15,25]$	172.65± 2.36	93.05± 5.51	93.59± 4.91	110.27± 4.67	112.22± 4.42

Future work

- Many applications where **user choices can be engineered through user-app interaction**
- Recommender systems, online social networks, social media, online advertising,…
- Enhanced choice and user decision models
- Testing with real data

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