Bandit 구현

세팅

- 총 ip 유저 수 : `206,380`
- ip 같으면 같은 유저 → 승객 개개인
- k → 20개의 그룹
    - ip 유저들을 20개의 그룹으로 분배
    - 컬럼 40개 이용하여 KMeans
        - 40개 컬럼:
            - app LDA topic 5개씩

          20개 : app+나머지 기초 변수(ip, device, channel, os)

          20개: 나머지 기초 변수 +
        - Kmeans에 사용되지 않는 나머지 4개의 컬럼: ip, app, time_dh , is_attributed

구현

- 시간 단위: 1시간
- 답지를 깔 때 걸리는 시간: 1시간
- 논문: 마지막 16일 데이터만 가지고 파라미터 업데이트

  → 여기서도 마지막 24시간만 가지고 업데이트 (*)
- 제한: 매 시간 마다 답을 확인해볼 수 있는 ip 개수

  → 바로 이전 시간의 ip 승객 수를 참고하여 그 수의 5%

논문 핵심 알고리즘

Subroutine 3: Test Allocation Sub-Routine

Input: Posterior distribution estimates $\hat{\alpha}_k, \hat{\beta}_k$ for each type $k \in K_t$, arrivals $A_{ke}(t)$ and budgets $B_e(t)$ for each type k and point of entry e, number of pipeline tests Q_k for each type k, and tuning parameters $\{c, \gamma\}$

for $k = 1: K_t$

$\hat{\alpha}_k \leftarrow \mathrm{c}\,\hat{\alpha}_k,\ \hat{\beta}_k \leftarrow \mathrm{c}\,\hat{\beta}_k$ *# prior widening*

Compute λ_k from Eq. (6) using $\hat{\alpha}_k, \hat{\beta}_k$

$\lambda_k \leftarrow$ pseudo-update index of type k (repeat Q_k times) *# account for pipeline tests*

$Y_k \leftarrow \sum_e A_{ke}(t)$ *# type k passengers not yet allocated a test*

for $e = 1: \mathcal{E}$

$Y_{ke} \leftarrow A_{ke}(t)$ *# type k passengers at point of entry e not yet allocated a test*

$C_e \leftarrow B_e(t)$ *# remaining (un-allocated) tests at point of entry e*

$N_{ke} \leftarrow 0$ *# initialize allocations*

end

end

while $\max_e C_e > 0$ **and** $\max_{k,\, e' \in \{e \mid C_e > 0\}} Y_{ke'} > 0$

$k^* = \mathrm{argmax}_k\{\lambda_k : Y_k > 0\}$

$e^* = \mathrm{argmax}_e\{C_e : Y_{k^*e} > 0\}$

$N_{k^*e^*} \leftarrow N_{k^*e^*} + 1$ *# allocate a test to a type k passenger at point of entry e*

$C_{e^*} \leftarrow C_{e^*} - 1,\ Y_{k^*e^*} \leftarrow Y_{k^*e^*} - 1,\ Y_{k^*} \leftarrow Y_{k^*} - 1$

$\lambda_{k^*} \leftarrow$ pseudo-update index of type k^*

end

return $\{N_{ke}\}_{k \in K_t, e \in \{1, \ldots, \mathcal{E}\}}$ *# number of tests allocated to each type at each port of entry*

Subroutine 1: Estimating Prevalence via Empirical Bayes

Input: *# of positives P_k, negatives N_k and tests T_k for each type k in the past 14 days of test results.*

for each color designation of countries $l \in \{\mathcal{W}_t, \mathcal{G}_t, \mathfrak{B}_t\}$

Compute M_{1l}, M_{2l} from Eq. (2) and (3)

$$\hat{\alpha}_l \leftarrow \frac{M_{1l}^2(1 - M_{1l})}{M_{2l}^2 - M_{1l}^2} - M_{1l},\ \hat{\beta}_l \leftarrow \hat{\alpha}_l \frac{(1 - M_{1l})}{M_{1l}}$$

for all types $k \in \mathcal{L}_l$ whose origin country is in l:

$\hat{\alpha}_k \leftarrow \hat{\alpha}_l + P_k$ and $\hat{\beta}_k \leftarrow \hat{\beta}_l + N_k$

end

end

$$\widehat{\alpha}_l = \frac{M_{1l}^2(1 - M_{1l})}{M_{2l}^2 - M_{1l}^2} - M_{1l}$$

$$\widehat{\beta}_l = \widehat{\alpha}_l \frac{(1 - M_{1l})}{M_{1l}}$$

$$M_{1l} = \frac{1}{|\mathcal{L}_l|} \sum_{k \in \mathcal{L}_l} \frac{P_k}{T_k} \tag{2}$$

$$M_{2l} = \frac{1}{|\mathcal{L}_l|} \sum_{k \in \mathcal{L}_l} \frac{P_k\,(P_k - 1)}{T_k(T_k - 1)} \tag{3}$$

- 문제점:
    - al을 업데이트 하는 과정에서 al이 음수가 나옴 → bl도 음수

```
ti: 14, group: 1, 0/1
m1l: 0 m2l: 0
al: 1 bl: 1

ti: 15, group: 15, 0/2
m1l: 0.0 m2l: 0.0
al: 1 bl: 1

ti: 16, group: 3, 16/310
m1l: 0.025806451612903226 m2l: 0.001252740369558409
al: -1.0023010996513302 bl: -37.83686651183771

ti: 17, group: 3, 13/194
m1l: 0.028769841269841268 m2l: 0.0016015020985199913
al: -1.0030189094833757 bl: -33.860534909800855

ti: 18, group: 3, 2/127
m1l: 0.024564183835182250 m2l: 0.0011697230397705834
al: -1.0022168995821927 bl: -39.79770978663482
```

- 수식을 조금 바꾸면 계속 같은 그룹만 검사하는 문제

```
ti: 14, group: 1, 0/1
m1l: 0 m2l: 0
al: 1 bl: 1

ti: 15, group: 15, 0/2
m1l: 0.0 m2l: 0.0
al: 1 bl: 1

ti: 16, group: 3, 16/310
m1l: 0.025806451612903226 m2l: 0.001252740369558409
al: 0.9506881964255237 bl: 35.88847941506352

ti: 17, group: 3, 12/194
m1l: 0.027777777777777776 m2l: 0.0014910536779324055
al: 0.9472538229128129 bl: 33.15388380194845

ti: 18, group: 3, 4/127
m1l: 0.025356576862123614 m2l: 0.0012477045757552888
al: 0.9516524438290008 bl: 36.57914080967722

ti: 19, group: 3, 4/98
m1l: 0.024691358024691357 m2l: 0.0011870845204178537
al: 0.9528768257956162 bl: 37.638634618926844
```

Specifically, consider countries of color $l \in \{\mathcal{W}_t, \mathcal{G}_t, \mathfrak{B}_t\}$, and the corresponding set of types $\mathcal{L}_l = \{k \in K_t : k \text{ is from a country in } l\}$. Let $T_k = P_k + N_k$ be the total number of tests (with results) allocated to type k over the last 16 days. Conditional on T_k, P_k is approximately binomially distributed with T_k

$$\lambda_k = \frac{\alpha_k}{\alpha_k + \beta_k}\left(1 - \gamma F_{\alpha_k+1,\beta_k}(\lambda_k)\right) + \gamma\lambda_k\left(1 - F_{\alpha_k,\beta_k}(\lambda_k)\right).$$

Gittins Pseudo-Update for type k

Input: $\hat{\alpha}_k, \hat{\beta}_k$ for type k

$\hat{r}_k^{EB} \leftarrow \dfrac{\hat{\alpha}_k}{\hat{\alpha}_k + \hat{\beta}_k}$

$\hat{\alpha}_k \leftarrow \hat{\alpha}_k + \hat{r}_k^{EB}$ and $\hat{\beta}_k \leftarrow \hat{\beta}_k + 1 - \hat{r}_k^{EB}$

Compute λ_k from Eq. (6) using $\hat{\alpha}_k, \hat{\beta}_k$

return λ