A Context-Aware, Fair, and Personality-Guided Group Sound Recommendation Framework

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1 Introduction

Group sound recommendation aims to select a single sound that is played for all members of a group while balancing individual preferences, contextual factors, and fairness constraints. Unlike individual recommendation, group recommendation inherently involves preference conflicts and requires explicit aggregation mechanisms [2].

Recent studies have demonstrated the importance of incorporating contextual information, personality traits, and fairness-aware strategies when recommending content to groups [3, 1]. This proposal presents a sequential group sound recommendation framework that integrates these dimensions into a unified mathematical formulation.

At each time step, the system outputs exactly one sound for the entire group.

2 Problem Formulation

Let

- $G = \{u_1, u_2, \ldots, u_n\}$ be a group of users
- $\mathcal{S}$ be the set of candidate sounds
- $t \in \{1, 2, \ldots, T\}$ denote discrete time steps
- $\mathbf{c}_t \in \mathbb{R}^k$ be the context vector at time t
- $\mathbf{e}_u \in \mathbb{R}^d$ be the embedding of user u
- $\mathbf{e}_s \in \mathbb{R}^d$ be the embedding of sound s
- $\mathbf{p}_u \in \mathbb{R}^m$ be the personality vector of user u

The objective is to select, at each time step t, a single sound $s_t^* \in \mathcal{S}$ that maximizes group satisfaction while respecting fairness and diversity constraints.

3 Context-Aware Individual Preference Modeling

Context-aware recommender systems adapt user preferences to situational factors such as time, environment, and social setting [2]. For each user–sound pair (u, s) at time t, the predicted preference score is:

$$\hat{r}_{u,s}^{(t)} = f(\mathbf{e}_u, \mathbf{e}_s, \mathbf{c}_t) \tag{1}$$

where $f(\cdot)$ is a learned scoring function, such as neural collaborative filtering augmented with contextual features.

4 Personality-Guided Preference Adjustment

Personality traits influence how users behave and compromise in group settings [3]. The group-level personality vector is computed as:

$$\mathbf{P}_G = \frac{1}{|G|} \sum_{u \in G} \mathbf{p}_u \tag{2}$$

Personality-adjusted individual preference is defined as:

$$\tilde{r}_{u,s}^{(t)} = \hat{r}_{u,s}^{(t)} + \alpha \cdot \mathrm{sim}(\mathbf{p}_u, \mathbf{P}_G) \tag{3}$$

where $\mathrm{sim}(\cdot, \cdot)$ denotes cosine similarity and $\alpha \geq 0$ controls the influence of personality alignment.

5 Activity-Based Fairness Weighting

Fairness in group recommendation can be improved by accounting for user activity and engagement patterns [1]. Let $a_u^{(t)}$ denote the cumulative activity of user u up to time t.

Normalized activity is computed as:

$$\bar{a}_u^{(t)} = \frac{a_u^{(t)}}{\max_{v \in G} a_v^{(t)} + \epsilon} \tag{4}$$

The fairness weight assigned to user u is then:

$$w_u^{(t)} = \beta \cdot \bar{a}_u^{(t)} + (1 - \beta) \frac{1}{|G|} \tag{5}$$

where $\beta \in [0, 1]$ controls the trade-off between activity-based influence and equal participation.

6 Group Utility Function

The group utility of sound s at time t is defined as:

$$U_G^{(t)}(s) = \sum_{u \in G} w_u^{(t)} \cdot \tilde{r}_{u,s}^{(t)} \tag{6}$$

This formulation aggregates individual preferences into a single scalar value representing collective satisfaction.

7 Least-Misery Constraint

To prevent extreme dissatisfaction among group members, a least-misery constraint is applied:

$$\min_{u \in G} \tilde{r}_{u,s}^{(t)} \geq \tau \tag{7}$$

The admissible set of sounds is therefore:

$$\mathcal{S}_t^{\text{adm}} = \{s \in \mathcal{S} \mid \min_{u \in G} \tilde{r}_{u,s}^{(t)} \geq \tau\} \tag{8}$$

8 Diversity-Aware Re-ranking

To avoid repetitive or monotonous playback, diversity is enforced through a similarity penalty. Let $\mathcal{H}_{t-1}$ denote the set of recently played sounds.

$$D(s) = \max_{s' \in \mathcal{H}_{t-1}} \text{sim}(s, s') \tag{9}$$

The final ranking score is:

$$U_G'^{(t)}(s) = U_G^{(t)}(s) - \gamma \cdot D(s) \tag{10}$$

where $\gamma \geq 0$ controls the strength of diversity enforcement.

9 Single-Sound Selection

At each time step t, exactly one sound is selected for playback:

$$s_t^* = \arg\max_{s \in \mathcal{S}_t^{\text{adm}}} U_G'^{(t)}(s) \tag{11}$$

This decision is repeated sequentially across time steps.

10 Sequential Update

After playing s_t^*, user activity and contextual state are updated:

$$a_u^{(t+1)} \leftarrow a_u^{(t)} + \Delta a_u \tag{12}$$

$$\mathbf{c}_{t+1} \leftarrow \text{Update}(\mathbf{c}_t) \tag{13}$$

This enables adaptive and fair recommendation over time.

11 Conclusion

This proposal formulates group sound recommendation as a sequential optimization problem integrating context awareness, personality-guided aggregation, and fairness constraints. By selecting a single sound per time step, the framework remains practically deployable while promoting long-term group satisfaction.

References

[1] A fairness group recommendation algorithm based on user activity. *Journal of Intelligent Information Systems*, 17:204, 2024.

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[3] Guangze Ye, Wen Wu, Liye Shi, Wenxin Hu, Xi Chen, and Liang He. A personality-guided preference aggregator for ephemeral group recommendation. *Information Sciences*, 639:118028, 2023.