Next activity prediction from individual daily mobility patterns

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Aim and Objectives

- Model the dynamics of individual's daily movements
- Predict human activities in the next time interval

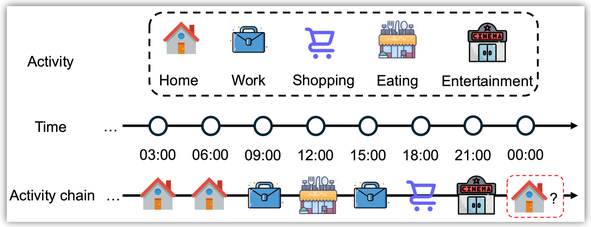

Figure 1: Illustration of the next activity prediction

Data Description

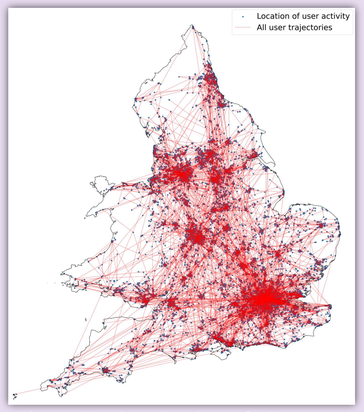

Figure 2: Visualisation of all individual trajectories

- Individual-level semantic trajectory data extracted from mobile phone applications
- The dataset consists of records in four dimensions: user ID, time, location and activity type
- There are 1475 users with 104,069 trajectory records within 30 days (November 2021)

- Human's daily activities:
  - home (H)
  - work (W)
  - eating and drinking (EaD)
  - education (Ed)
  - entertainment (En)
  - frequent shopping (S1)
  - non-frequent shopping (S2)
  - others (O)

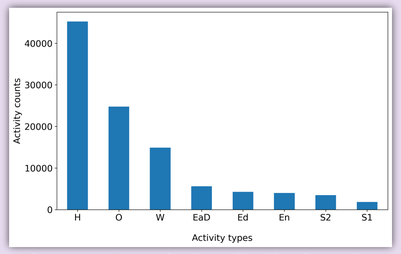

Figure 3: Quantitative distribution of different types of activities

Methodology

- Use embedding layer to learn semantic relationship
- Construct training and test datasets using sliding windows

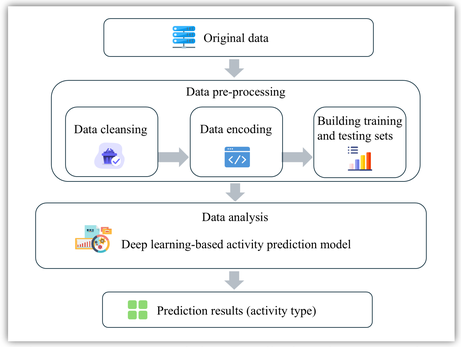

Figure 4: Next activity prediction framework

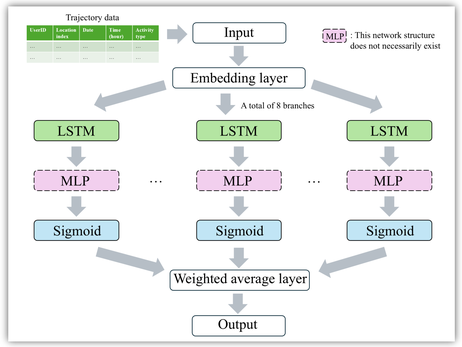

Figure 5: Structure of proposed MTL-LSTMs model

- Multi-category classification task
- The primary challenge lies in the imbalance among activity categories
- Transform the task into multiple binary classification tasks, leveraging concepts from ensemble learning and multi-task learning

Results and Findings

Calculation formulas for different metrics

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}}$$

$$\text{Precision} = \frac{\text{TP}}{\text{TP} + \text{FP}}$$

$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FN}}$$

$$\text{F1-score} = 2 \cdot \frac{\text{Precision} \cdot \text{Recall}}{\text{Precision} + \text{Recall}}$$

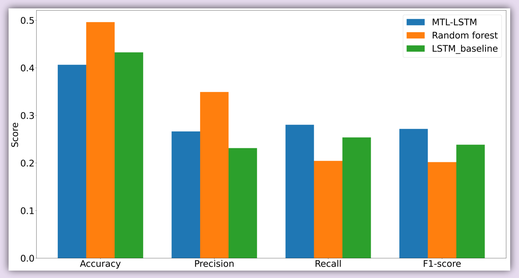

Figure 6: Evaluating the model performance using various performance metrics

- Among these metrics, the highest score in MTL-LSTM is captured in recall
- The prediction results illustrate higher accuracy for routine (regular) activities, such as home, work, and education
- Less structured activities, such as eating, entertainment, and shopping, obtain lower accuracy from individuals' daily activity chains

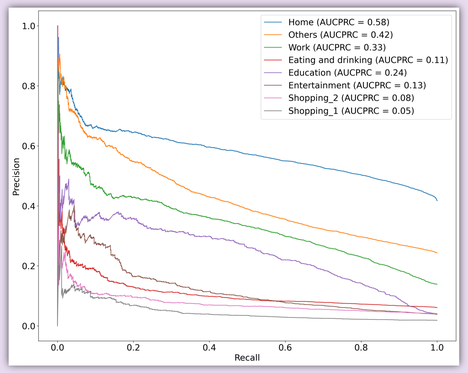

Figure 7: Precision-recall curve for MTL-LSTM

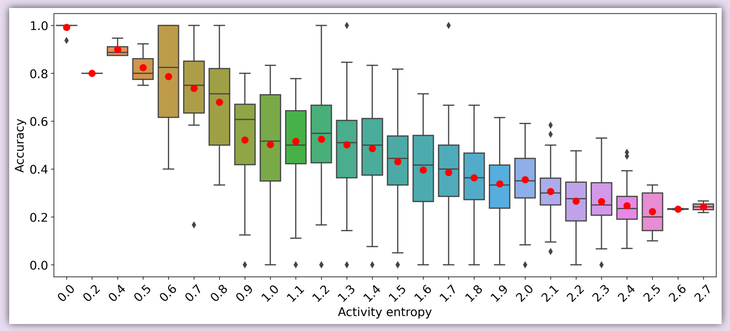

Figure 8: Relationship between activity entropy and prediction accuracy

- The inverse relationship between activity entropy and prediction accuracy, i.e., lower entropy with higher prediction accuracy

Conclusion

- The proposed approach effectively improves recall, particularly for routine activities, while highlighting challenges in predicting less structured behaviours
- Further refinement of multi-task learning strategies and ensemble techniques can enhance prediction accuracy for irregular activities

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