Human Behavior Understanding

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1 Research framework

Figure 1 shows the research framework of human behavior understanding, and its main components include data capture, modeling and analysis, performance evaluation, and applications.

Data capture: In addition, due to the diversity of data sources, researchers can capture various formats of data, such as audio, video, text, and image, which increases the possibility of human behavior modeling from multiple aspects.

Modeling and analysis: In specific, it mainly consists of three subcomponents, i.e., observed patterns, inference algorithm, and model hypotheses.

Performance evaluation: In particular, we expect there should be several universal benchmarks that can be used for all researchers to test their studies equivalently. Further, the performances can be evaluated using a set of metrics, for example, the employed algorithm should be efficient in time, space and energy, and the results are expected to be accurate and precise.

Applications: Effective human behavior understanding can be applied into many applications, such as personalized recommendations, smart home, public opinion monitoring, urban planning, disease treatment, and anti-terrorism.

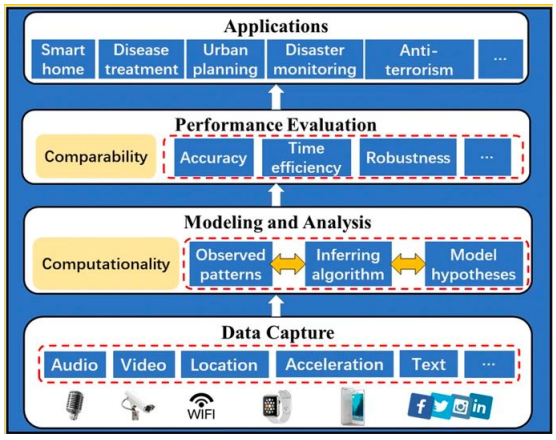

Figure 1: Research frame of human behavior understanding

2 Research challenges

Human behavior understanding faces many challenges, which can be summarized from the following three perspectives.

(1) Challenges from human behavior itself. there exist some characteristics of human behavior itself that are difficult to sense and analyze, e.g., capriciousness, evolution, and multiple granularity.

(2) Challenges from the data. We identify following key research challenges that may be involved, i.e., data fragmentation, data heterogeneity, data representativeness, data sparsity, imbalanced data distribution, and spatial-temporal correlation.

(3) Challenges from modeling and evaluation. There have been various models proposed for human behavior recognition and prediction, and these models usually regard the behavior computable as the default. However, human behavior is usually related to many dynamic and uncertain factors. Therefore, theoretical verification on computationality is essential yet difficult.

3 Ten most important problems

Based on the challenges discussed above, we identify ten most important problems in human behavior understanding. The first three come from challenges related to human behavior itself, problems No. 4–8 are related to the data, and the last two are derived from the challenges of modeling and evaluation.

(1) Behavior evolution
(2) Multi-aspect of human behavior
(3) Capriciousness
(4) Data fragmentation
(5) Data heterogeneity
(6) Spatial-temporal correlation
(7) Data representativeness
(8) Data sparsity
(9) Computationality
(10) Comparability

Detailed introduction can be viewed:
https://mp.weixin.qq.com/s/9H8IW07tUNnpJaAFhNkbkg

4 Discussion

We envision the following possible ways that would be helpful for resolving the challenging problems.

4.1 Interdisciplinary collaboration

Understanding our human being needs the collaboration of experts from multiple related disciplinaries. For instance, understanding the evolution and capriciousness of human behavior should combine the knowledge in both psychology and sociology, which can explore how human behavior evolves and why human behavior is capricious and what can affect human behaviors. It is studied users' shopping intention can be affected by others' comments (Morris et al. 2014). With the support of these studies, we can further explore whether and how the factors can be quantified.

4.2 Cross-organization collaboration

Different organizations need to collaborate to deal with the challenges derived from the data. The most primary task for data fragmentation is merging/aggregating fragmented data from different devices or platforms to comprehensively understand human behavior pattern. Only if we could link the same identity from different data sources, can we merge the fragmented data of human behavior to build universal models. Some possible approaches are discussed in Yi et al. (2018), including structure/content-based identity linking methods by leveraging graph-based techniques. Furthermore the data from different sources would be heterogeneous. Thus different organizations should work together to share the data and use a universal model to describe the data.

4.3 Leveraging crowd power

Crowd power can be leveraged for human behavior understanding in several aspects. First, crowdsourced footprints can be used for understanding large-scale community activities. This is effective to solve the problem of collecting sensory data of community-scale users. Second, training data uploaded by the crowd would be valuable for behavior recognition. Third, ground truth data is significant in behavior understanding. While manual annotation of large-scale dataset is time-consuming, we can leverage human intelligence of crowd power to fulfill the annotation task (von Ahn et al. 2008).

4.4 Focus on fundamentals

There have been early works that attempt to tackle the challenging problems and in some time make the field forward. But we need to focus more on the fundamentals, such as common principles, theories, and benchmarks. For instance, it is necessary to conduct the theoretical exploration on the extent that human behavior can be sensed or understood. This is related to the properties of specific human behavior, and may also depend on the sensing technology as well as the characteristics of collected data. It is also essential to build benchmarks for human behavior understanding. For example, based on the characteristics of different localization technologies (e.g., infrared, RFID, GPS, Bluetooth,

Wi-Fi), we should try to define a standard experimental environment for each technology and propose the bound of the location results.