UTS UNIVERSITY OF TECHNOLOGY SYDNEY

Decision Briefing Generation on Meteorological Social Events

by Kaize Shi

Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

under the supervision of Xueping Peng and Guodong Long

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Kaize Shi, declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Engineering and Information Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of the requirements for a degree at any other academic institution except as fully acknowledged within the text. This thesis is the result of a Collaborative Doctoral Research Degree program with Beijing Institute of Technology. This research is supported by the Australian Government Research Training Program.

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ABSTRACT

Meteorological disasters have the characteristics of suddenness, complexity, dynamics, and diversity, which have inflicted severe challenges on emergency decision support services in disaster environments. Nowadays, mobile internet technologies such as smartphones, social networks, wearable devices, and high-speed communication are widely used, making each user a ubiquitous social sensor integrating human and machine. Social sensors collect data from mobile devices worn or carried by humans, intuitively perceive the environmental conditions associated with a meteorological disaster through human senses, and have the advantages of comprehensive coverage, communication in real-time, and low cost.

Decision briefing is an effective support mode of emergency management services for sudden meteorological disasters, and it is also the primary way to deliver meteorological decision knowledge. This thesis focuses on the critical technologies for the automatic generation of meteorological event knowledge-enhanced decision briefing based on social sensor signals, providing meteorological decision support services focusing on accurate knowledge mining, efficient information integration, and formalized knowledge representation for decision-makers in the decision process of sudden meteorological disasters. The main research foci and innovations of this thesis are as follows:

1. Co-occurrence feature-based sudden meteorological event detection: Aiming at the low detection accuracy of meteorological events caused by limited coverage of physical sensor signal, poor timeliness, and lack of co-occurrence feature mining of meteorological events in previous research, **this thesis proposes a sentence-level feature-based meteorological event detection model**. The model is based on social sensor signals and introduces prior meteorological knowledge through the pre-trained language model in sentence vectorization. The wide-grained capsule network mines the attributes of the independent and co-occurrence features of meteorological events and then undertakes the real-time synchronous detection of multi-category co-occurrence meteorological events in a specific period. The proposed model achieves quantitative evaluation results of 0.941, 0.862, 0.738 and 0.795 on $Accuracy$, P_{micro}, R_{micro} and $F_{micro-1}$, respectively, which is significantly better than other baseline models.

2. Multiple knowledge-enhanced meteorological decision briefing generation: Aiming at the low decision efficiency caused by information complexity, high chaos, and a large amount of data in the sudden meteorological disaster environment, **this thesis proposes a multiple knowledge-enhanced summarization model**. The model comprises a cascade structure of a summary generation module and a multiple knowledge

enhancement module, which automatically generates meteorological decision briefing content by guiding the summary generation process with specific meteorological event and geographical location knowledge in the social sensor signal. The proposed model achieves 0.2025, 0.0807, and 0.1740 of the $ROUGE-1$, $ROUGE-2$, and $ROUGE-L$ in the content evaluation and 0.656 of F_1 score in the sentiment evaluation, significantly better than other baseline models.

3. Meteorological event knowledge-enhanced decision briefing optimization: Aiming at the weak decision support serviceability caused by the chaotic language style, colloquial text, and poor formatting of the social sensor signals-based meteorological briefing content, **this thesis proposes an event knowledge-enhanced briefing optimization module**. This module comprises a text form judgment model, a formalization words detection model, and an event knowledge guided text formalization model, which optimizes the transfer of the meteorological briefing content by calculating the text formalization judgment threshold, formalization word weight, and generates formalized words. The proposed model achieves quantitative evaluation results of 21.489 on the $BLEU$, which is significantly better than other baseline models.

In addition, this thesis reports on the construction of a prototype application of the meteorological decision briefing integrated with the above research foci, which showcases the use of social sensor signals to provide feedback on daily meteorological events, then provides decision support services based on meteorological decision briefing. This thesis presents interdisciplinary research on artificial intelligence, social computing, meteorological data mining, emergency management, and intelligent decision support services, which is a comprehensive analysis and extended application of interdisciplinary issues. This research has significant application value for improving the decision efficiency of meteorological departments and reducing the loss caused by sudden meteorological disasters.

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The end of one story is the beginning of another. Each man is the architect of his fate. Think. Change. Do.

List of Publications

Related to the Thesis :

1. **Kaize Shi**, Xueping Peng, Hao Lu, Yifan Zhu, Zhendong Niu: Application of Social Sensors in Natural Disasters Emergency Management: A Review. IEEE Transactions on Computational Social Systems. 2022, doi: 10.1109/TCSS.2022.3211552.

2. **Kaize Shi**, Changjin Gong, Hao Lu, Yifan Zhu, Zhendong Niu: Wide-grained capsule network with sentence-level feature to detect meteorological event in social network. Future Generation Computer Systems. 102: 323-332 (2020)

3. **Kaize Shi**, Yusen Wang, Hao Lu, Yifan Zhu, Zhendong Niu: EKGTF: A knowledge-enhanced model for optimizing social network-based meteorological briefings. Information Processing & Management. 58(4): 102564 (2021)

4. **Kaize Shi**, Hao Lu, Yifan Zhu, Zhendong Niu: Automatic generation of meteorological briefing by event knowledge guided summarization model. Knowledge-Based Systems. 192: 105379 (2020)

5. **Kaize Shi**, Xueping Peng, Hao Lu, Yifan Zhu, Zhendong Niu: Automatic Generation of Meteorological Briefing by Multi Knowledge Enhanced Summarization Model. (Under review)

6. **Kaize Shi**, Xueping Peng, Hui He, Kun Yi, Zhendong Niu: Multi-KGS: A Multiple Knowledge Guided Summarization Model for Generating Social Network-based Meteorological Decision Report. (Under review)

Others :

8. Yifan Zhu, Qika Lin, Hao Lu, **Kaize Shi**, Donglei Liu, James Chambua, Shanshan Wan, Zhendong Niu. Recommending Learning Objects through Attentive Heterogeneous Graph Convolution and Operation-Aware Neural Network. IEEE Transactions on Knowledge and Data Engineering. (2021)

9. Qika Lin, Yifan Zhu, Hao Lu, **Kaize Shi**, Zhendong Niu: Improving University Faculty Evaluations via multi-view Knowledge Graph. Future Generation Computer Systems. 117: 181-192 (2021)

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15. Changjin Gong, **Kaize Shi**, Zhendong Niu: Hierarchical Text-Label Integrated Attention Network for Document Classification. HPCCT/BDAI 2019: 254-260

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TABLE OF CONTENTS

List of Figures

List of Tables

Table **Page**