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Dynamic time prediction for electric vehicle charging based on charging pattern recognition

Key words: Charging mode; Charging time; Random forest; Long short-term memory (LSTM); Simplified particle swarm optimization (SPSO)

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Motivation

1.Charging time prediction is of great significance in the operation and charging safety of electric vehicles (EVs), and different EVs have different battery management systems (BMSs) and charging modes.

2. To improve the accuracy of charging time prediction, the charging mode should be considered and a clustering method can be used to classify modes.

3. To solve the problem that the LSTM accuracy is affected by manual parameter setting, it is necessary to select an intelligent optimization algorithm to determine the appropriate parameters.

4. An improved simplified particle swarm optimization (ISPSO) can be used to obtain appropriate parameters, but it may fall into local optimum due to the lack of a velocity term.

Main idea

1. A new KNN-DWDPC-RF method is proposed to classify charging modes.
2. The LSTM network is used to predict charging time of EVs with classified charging modes. An improved simplified particle swarm optimization (ISPSO) algorithm, based on SPSO and the velocity mean, is proposed to determine the LSTM's parameters, and improve the prediction effect of LSTM.
3. Because the speed term is omitted in ISPSO, it is not limited by speed. A large amount of training data may lead to a local optimum at the later stage of training, and the strong tracking filter can be used to improve this problem.

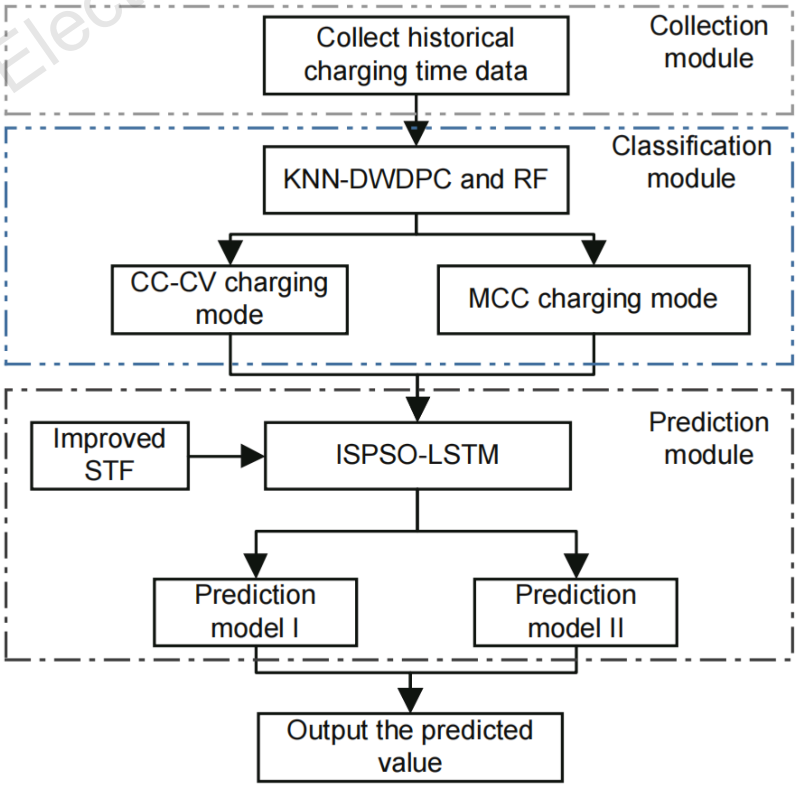
Method

1. The proposed method can be divided into collection, classification, and prediction modules.

2. The collection module queries and pre-processes data from a time-series database.

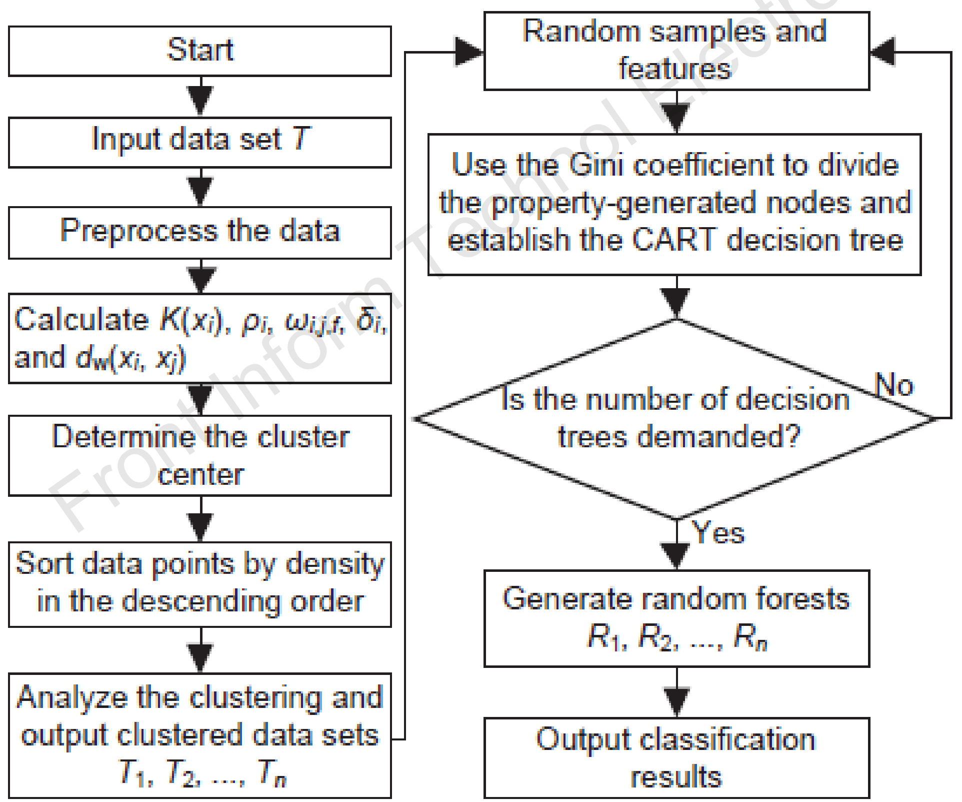
3. The classification module uses improved RF to classify charging modes based on charging data.

4. The prediction module uses improved LSTM to forecast charging time.



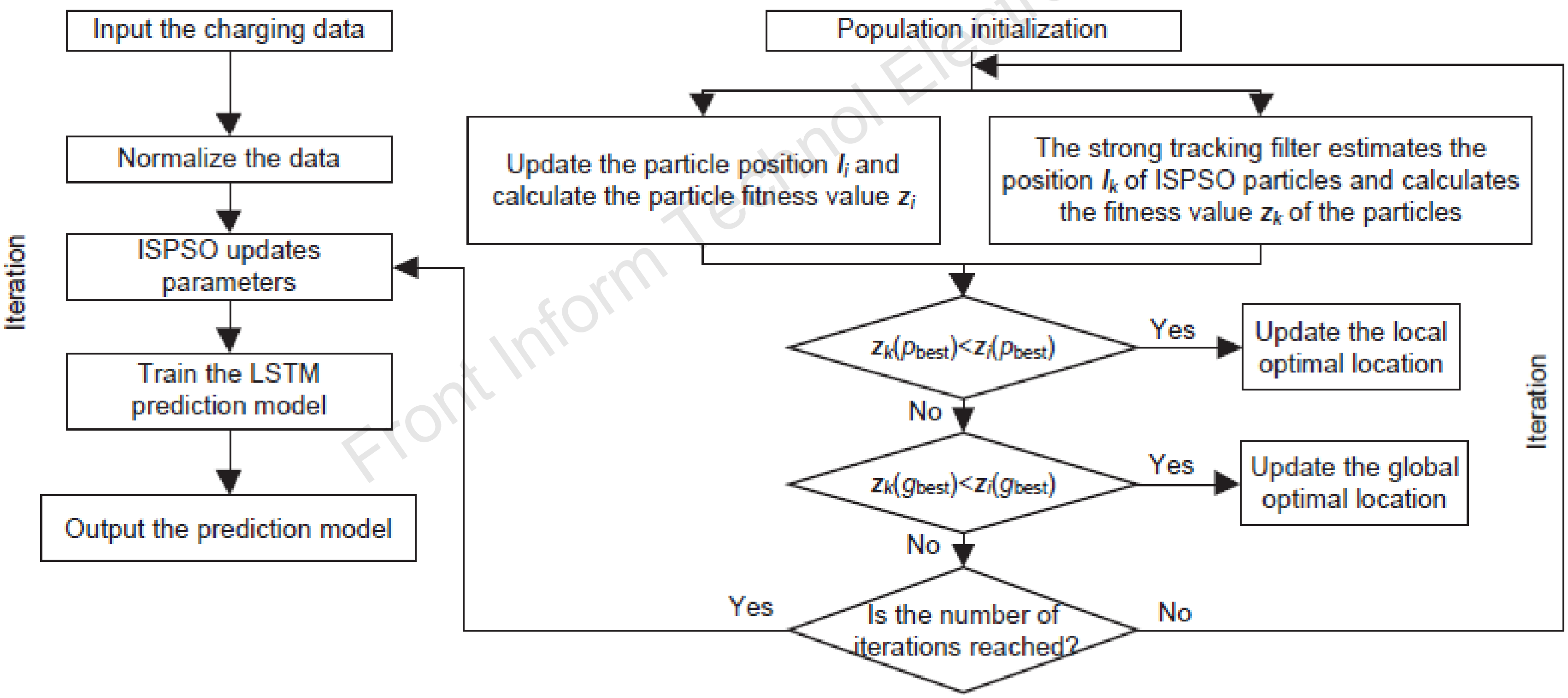
Method (KNN-DWDPC-RF)

1. A random forest moethod, which is improved by KNN-DWDPC, is used to classify charging modes.



Method (ISPSO-LSTM)

1. In order to predict charging, an improved LSTM method is proposed.



Major results

It can be seen that in two different charging modes, the prediction effect of charging data after classification is far better than that without classification.

Table 5 Mean absolute percentage error (MAPE) under different methods

Method	MAPE (%)
LSTM (unclassified)	8.385
LSTM (classified)	4.598
PSO-LSTM	3.530
ISPSO-LSTM	2.478
ISPSO-LSTM-STF	0.963

Major results (Classification)

charging mode classification

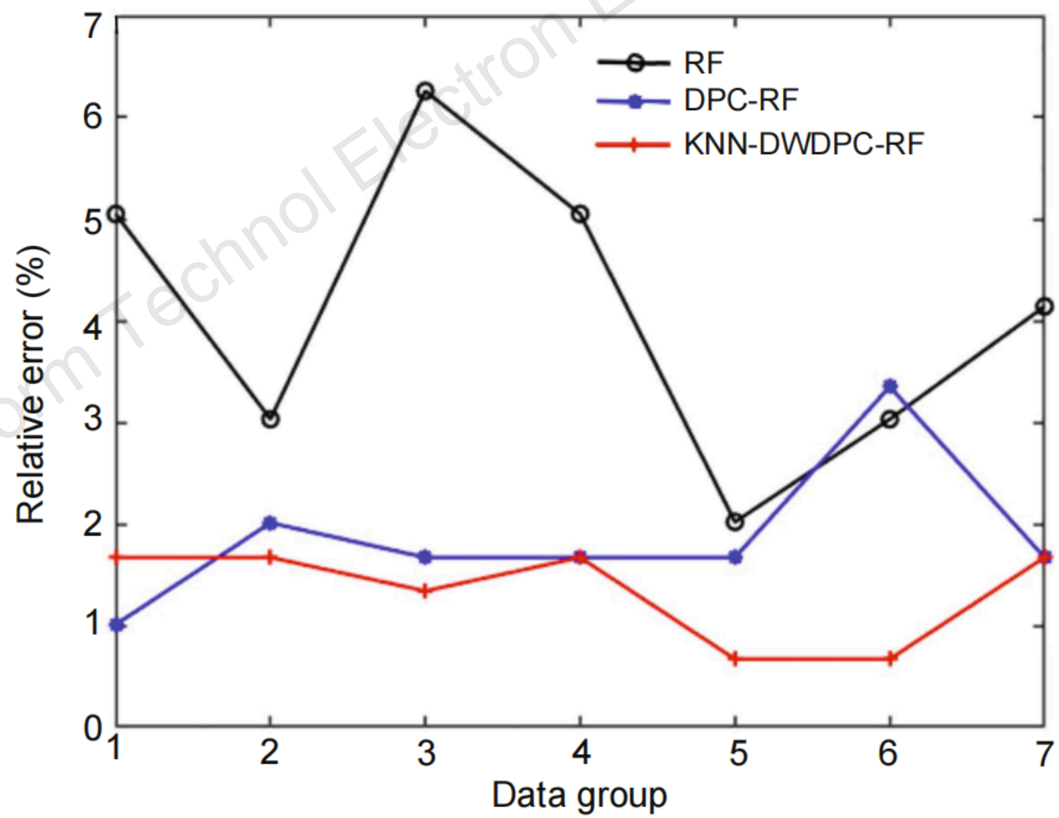


Fig. 8 Comparison of accuracy under different classification methods

Conclusions

1. In this paper, a novel charging time prediction method has been proposed to solve the problem of low accuracy encountered by traditional methods due to the lack of charging mode recognition.

2. An improved DWDPC method based on KNN has been used to classify EV charging modes according to the charging voltage and current.

3. Then charging time has been predicted by an LSTM algorithm whose parameters were optimized by ISPSO and STF.

4. It has been proved by experiments that the proposed method can effectively improve the charging time prediction accuracy and has real engineering value.

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