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Early warning of excessive heat effect on human health using deep learning models

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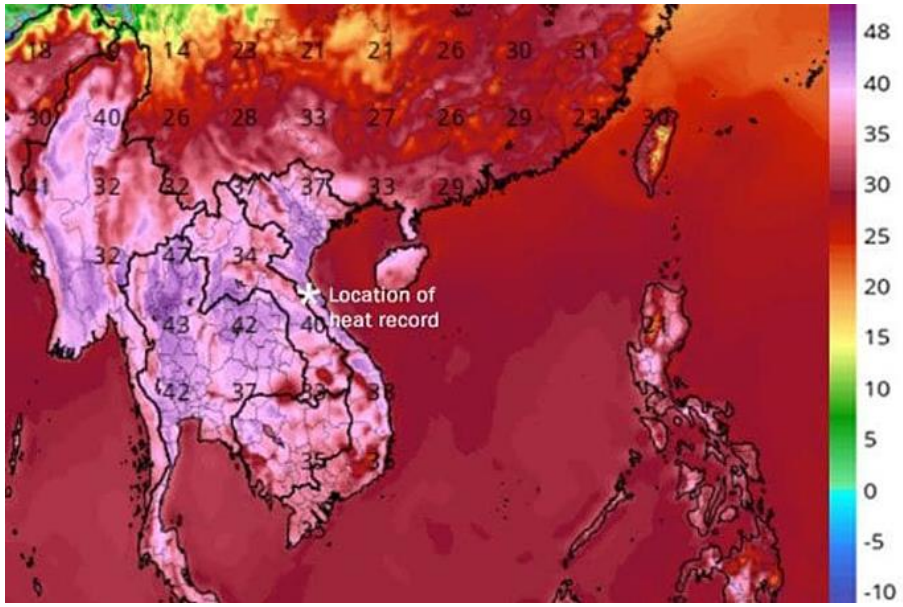
Introduction

- **Excessive heat** means any temperature above 40 ^{o}C.
- Excessive heat is dangerous for human health because it can cause heatstroke, cramps, and heat exhaustion.
- Effect of excessive heat on human health can be measured using **heat index**.
- **Heat index** (HI, unit: Celsius degree): A measure of how hot people really feels when relative humidity is factored with the actual air temperature.

Introduction

Global warming → Increase frequency of excessive heat → *Especially tropical & sub-tropical regions*

Map of heat index in Vietnam



- Vietnam: One of the Southeast Asian countries mostly impacted by global warming.
- Heat index in Vietnam: Frequently high (> 40 ^{o}C).
- The most vulnerable targets from excessive heat: children, older adults, outside workers, and people with disabilities.
- A forecast of heat index: Help people in Vietnam more adapt with high temperature from heat waves over the country.

Challenges and Objectives

Challenges of this study:

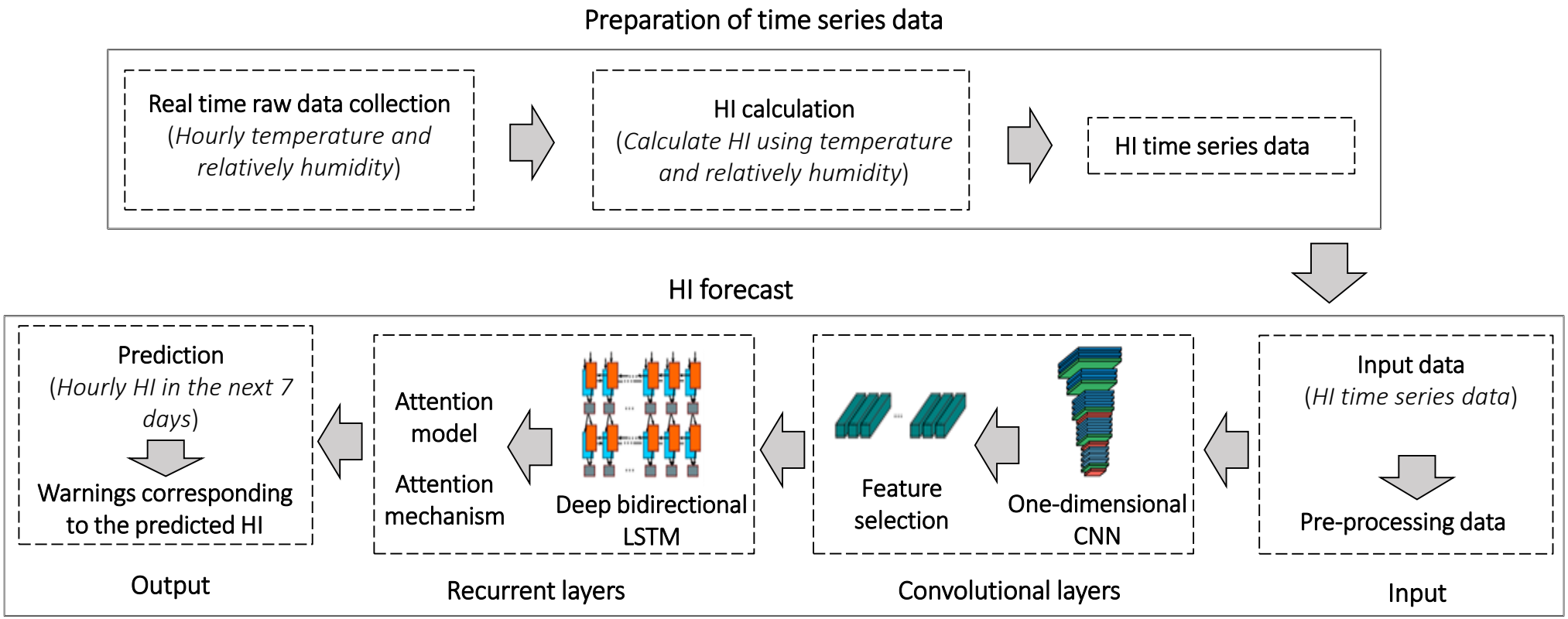
- Outdoor environment, where other factors can affect heat index (for example: climate change).
- Missing and corrupted data.
- Non-stationary data.

Objectives

- To develop novel deep learning models to forecast heat index.
- Provide early warnings of excessive heat effect on human health based on the predited heat index.

Method

Proposed end-to-end model for forecasting heat index

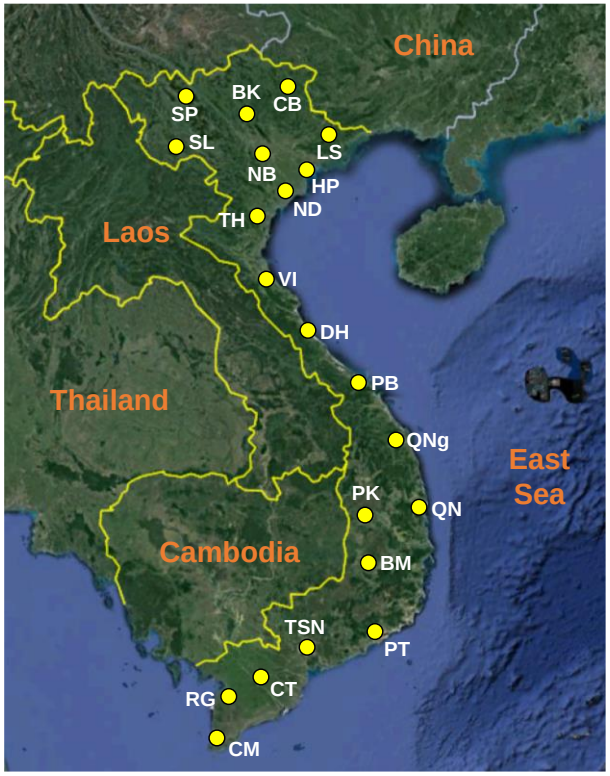


Method – Step 1: Preparation of time series data

Real time raw data collection
(*Hourly temperature and relatively humidity*)

HI calculation
(*Calculate HI using temperature and relatively humidity*)

HI time series data



Stations for downloading time-series data

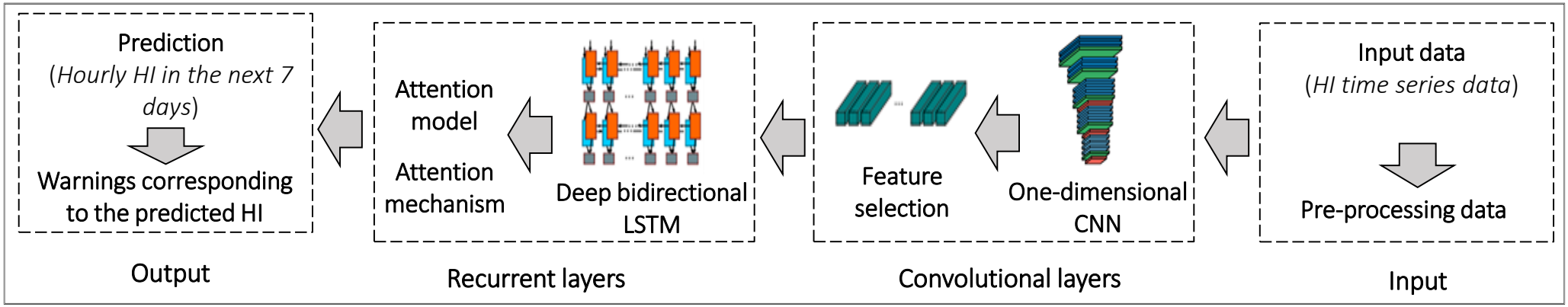
Equation for calculating heat index (HI)

HI = -42.379 + 2.04901523*T + 10.14333127*RH
- 0.22475541*T*RH - 0.00683783*T*T -
0.05481717*RH*RH + -0.00122874*T*T*RH +
0.00085282*T*RH*RH - 0.00000199*T*T*RH*RH

where RH: relatively humidity, T: air tempeature

(Source: Lans P. Rothfusz., 1990)

Method – Step 2: Forecast heat index



- End-to-end Convolutional Recurrent Neural Network (CRNN) model with attention mechanism.
  - Feature learning based on 1-D CNN.
  - Deep Bi-LSTM for heat index forecasting.
  - CRNN framework with an attention mechanism to capture more stochasticity within the heat index.

Method – Step 3: Provision of early warning

❖ Based on the forecasted HI, warnings of excessive heat effect on human health are provided following this table.

Table 1. Warnings and effect of the heat index (HI)

Heat index	Effect on human health	Warning levels
27–32 °C	Continuing activity could result in heat cramps.	Caution
27–41 °C	Heat cramps and heat exhaustion are possible.	Extreme caution
41–54 °C	Heat cramps and heat exhaustion are likely.	Danger
Over 54 °C	Heat stroke is imminent.	Extreme danger

Expected outcomes

- Outcomes: Forecast model of excessive heat effect on human health and spatial prediction of heat index over Vietnam.

- Additional outputs: Expected to be international publications in reputable journals or conferences, final projects of students, and workshops for respective stakeholders for awareness of the developed model.

Study contribution

- This study introduces a solution using CRNN+ attention model for forecasting HI, aiming to provide early warnings of heat excessive effect on human health.

- Through this study, strategic cooperation among domestic/international research teams and related stakeholders is established to get feedback and improve the research projects.

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