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Machine Learning for Assessing Soil Liquefaction Risk in Seismic Zones

by :
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Concept Note and Implementation

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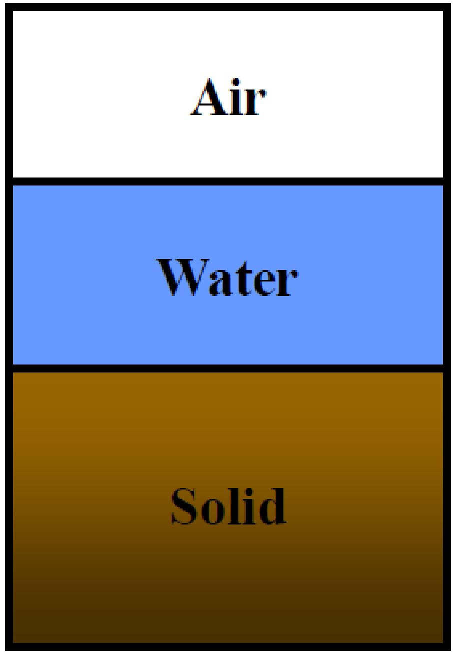
Background



Where:
σ≡Total normal stress(F/A)
σ'≡Effective normal stress
u≡Pore water pressure

- **Liquefaction** is the process in which a mass of soil loses its strength and starts to behave like a liquid
- **Need?**
- Severe damages
- Financial burden

Loose sand + HIGH GWT + cyclic loading = u↑ + σ constant

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Background

The forms of damage

- Tilting
- Sinking
- Floating
- Lateral movement

IkuoTowhata , GEE , 2008 Springer

Objectives

- Building a liquefaction prediction model By analyzing historical earthquake data and geotechnical parameters
- Using the model as a helping tool in mitigating the risks associated with liquefaction

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SDG Relation

- Risk management project
- Directly relevant to SDG 11 (Sustainable Cities and Communities)

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Data

Data Collection

- Source(s) of the dataset:geotechnical reports, seismic surveys, and academic research papers
- Preprocessing steps during data collection (CPT data sets as an example):

I. Data : five Excel files were imported

II. unique columns specific to individual datasets were removed

III. The datasets were then merged into a single data frame

IV. After merging, rows containing any NaN values were dropped

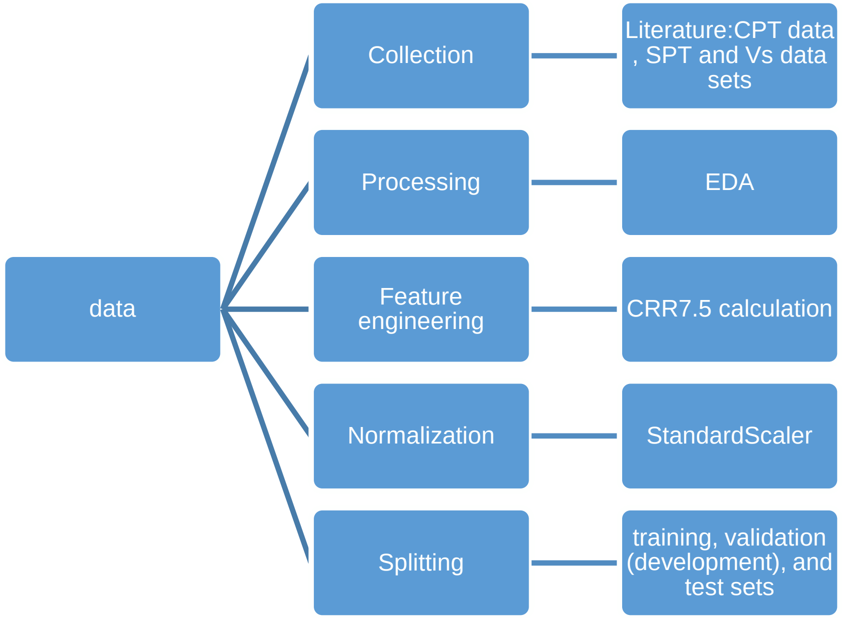


Table 1 distribution of cases across non-liquefied and liquefied conditions

cases	SPT	CPT	Vs
Non -Liquefied	412	511	505
Liquefied	311	175	585

Exploratory Data Analysis (EDA) and Feature Engineering

- feature engineering :

i. The calculation of CRR7.5 is based on the IS1893-1, 2016 standard

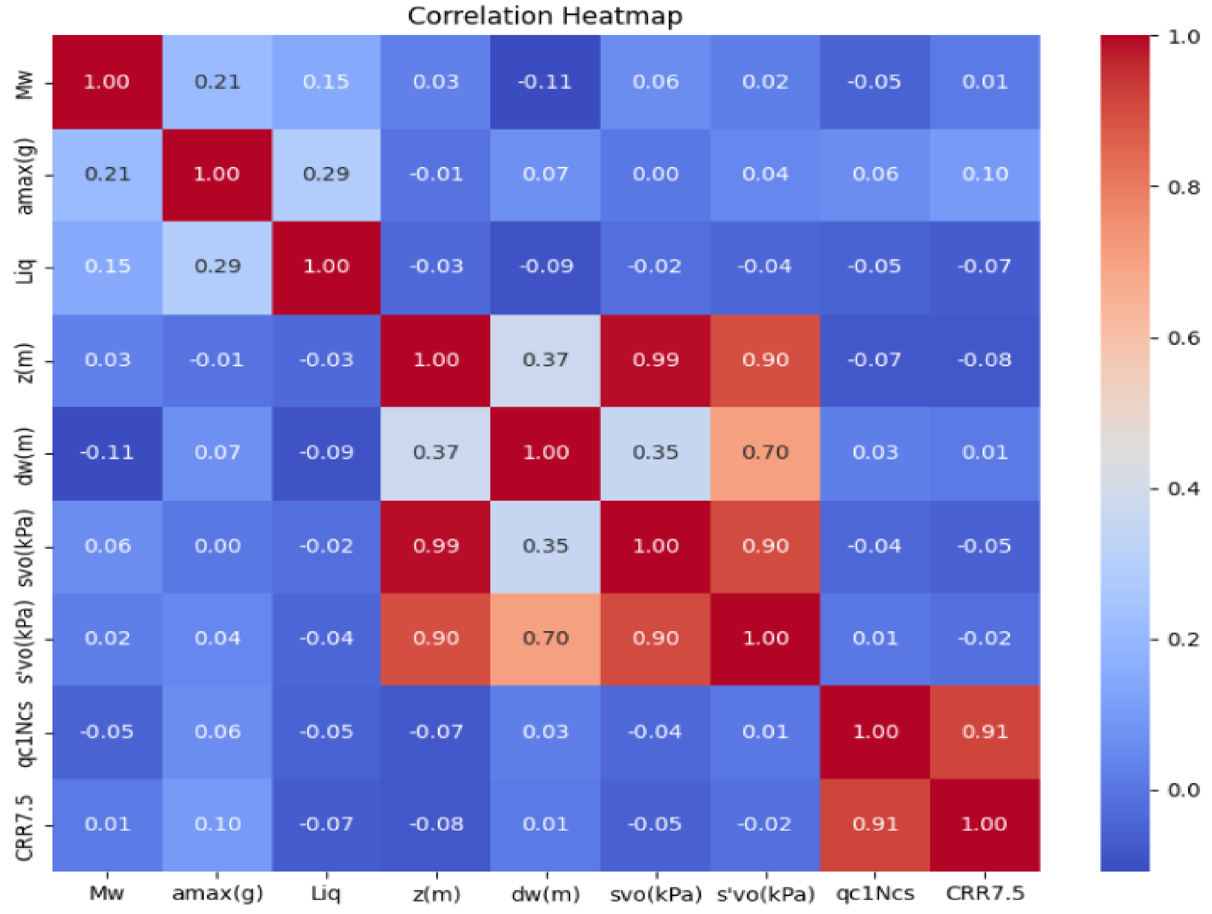
ii. to harmonize data from different soil tests into a common metric

CPT test :((qC1N)CS

SPT test : (N1)60cs

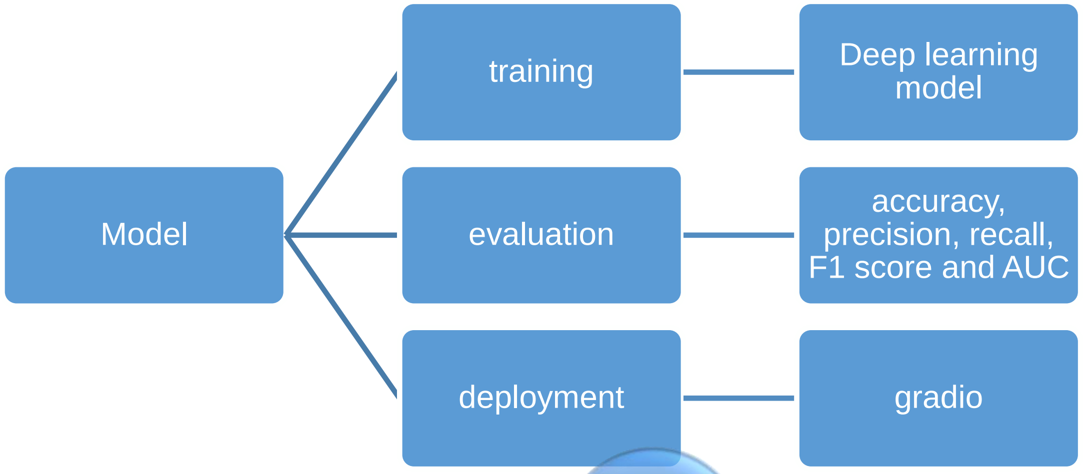
Vs: test Vs1

- Encoding: transforming the 'Liq' column in `data` from string values ('yes', 'no') to binary numeric values (1, 0).



Model

Model Selection and Training

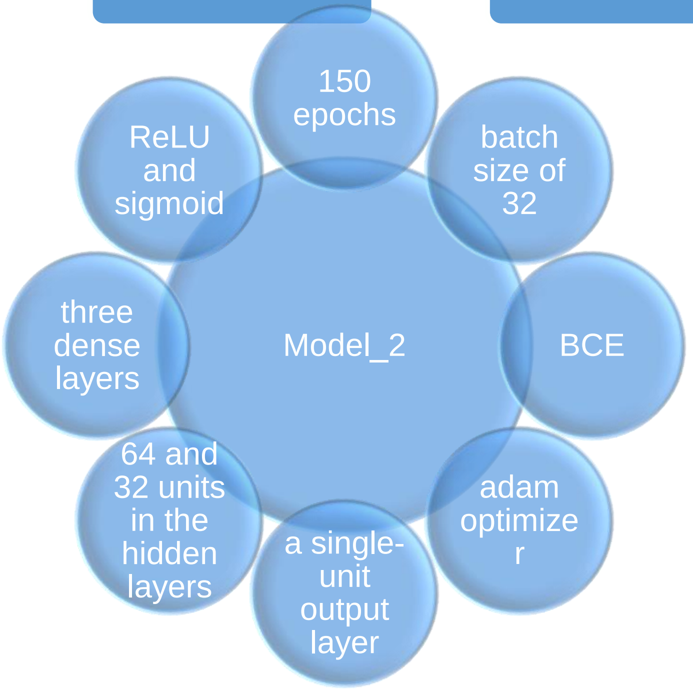


- DL: Compared to traditional methods, offers superior accuracy and reliability ,capture non-linear relationships within data , capacity to learn from diverse datasets , requires substantial computational resources and expertise.
- Details on training the model:model_2

i. ReLU and sigmoid activations

ii. 3 dense layers , units (64 and 32 units in the hidden layers) ,a single-unit output layer

iii. 'adam' optimizer , 'binary_crossentropy' loss function ,batch size of 32 over 150 epochs.



Model Evaluation and Hyperparameter Tuning

Table 1 qc1Ncs_MODELs evaluation metrics

del	Accuracy (Training)	Precision (Training)	Recall (Training)	F1 Score (Training)	AUC (Training)	Accuracy (Validation)	Precision (Validation)	Recall (Validation)	F1 Score (Validation)	AUC (Validation)	Accuracy (Test)	Precision (Test)	Recall (Test)	F1 Score (Test)	AUC (Test)
el_2	0.9108	0.9063	0.9811	0.9422	0.9686	0.7887	0.8033	0.9423	0.8673	0.7753	0.8889	0.9298	0.9298	0.9298	0.9135
el_3	0.8794	0.8867	0.9599	0.9219	0.9422	0.8028	0.8276	0.9231	0.8727	0.8077	0.8611	0.9123	0.9123	0.9123	0.9404
_12	0.9073	0.9095	0.9717	0.9396	0.9483	0.7746	0.8000	0.9231	0.8571	0.7864	0.8472	0.8966	0.9123	0.9043	0.9193
_13	0.8811	0.8991	0.9458	0.9218	0.9320	0.8028	0.8276	0.9231	0.8727	0.7804	0.8472	0.8966	0.9123	0.9043	0.9263

Model Refinement and Testing

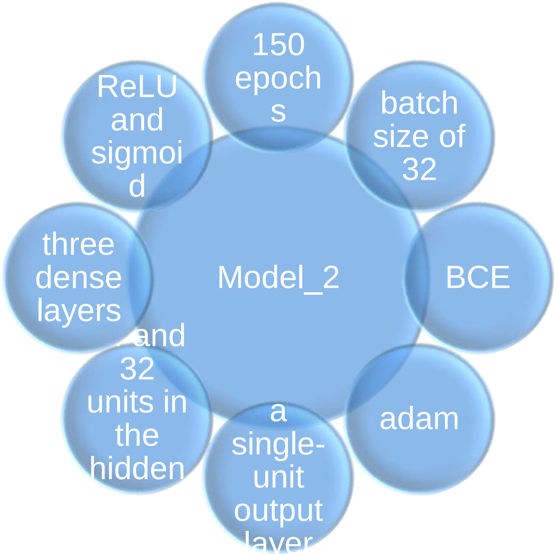
- Overview of the refinement phase
- Techniques used for model improvement
- Overview of the test submission phase
- Metrics and results on the test dataset

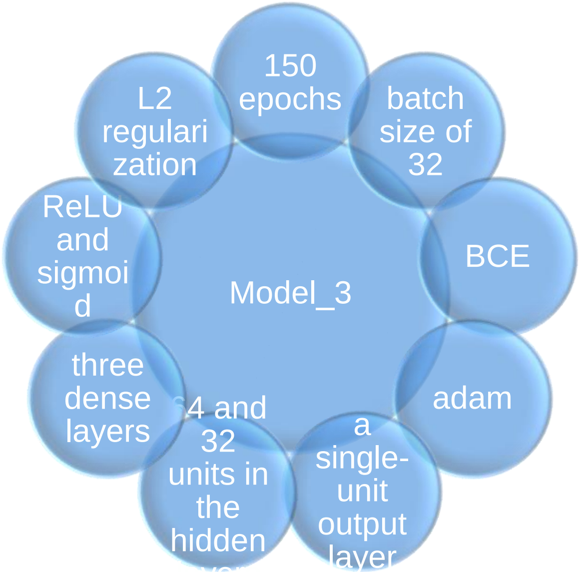
Result

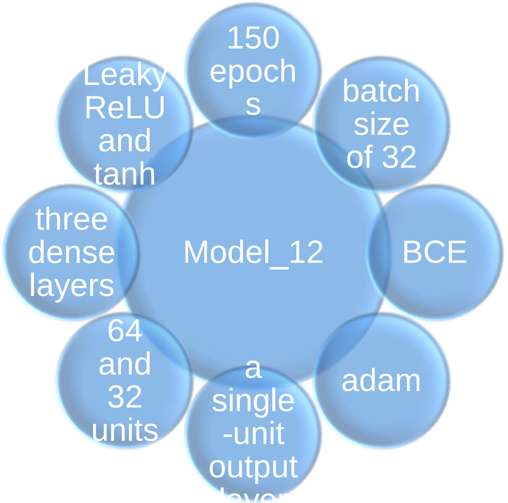
Evaluation Results

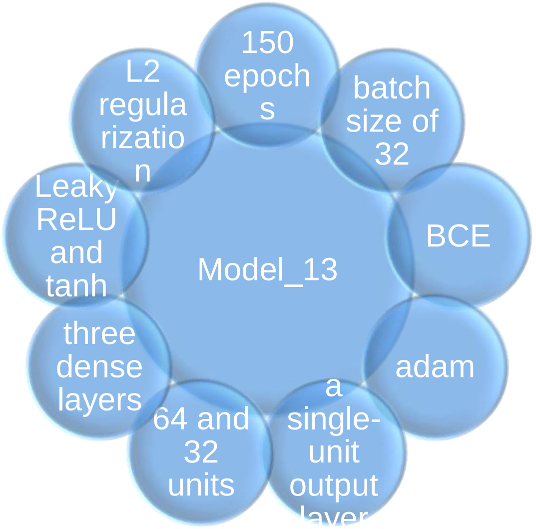
Accuracy (testing)

- qc1Ncs_MODELS: Model_13=84.72%
- CPR_CRR_MODELS: Model_2 =87.5%
- (N1)60cs_MODELS: Model_2=82.19%
- SPT_CRR_MODELS: Model_12=75.14%
- Vs_MODELS : Model_13=69.81%
- Vs_MODELS: Model_13=72.64%
- CRR_MODELS: Model_3=72%









Deployment

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Deployment

- Overview of the deployment phase
- Model serialization, serving, and API integratior

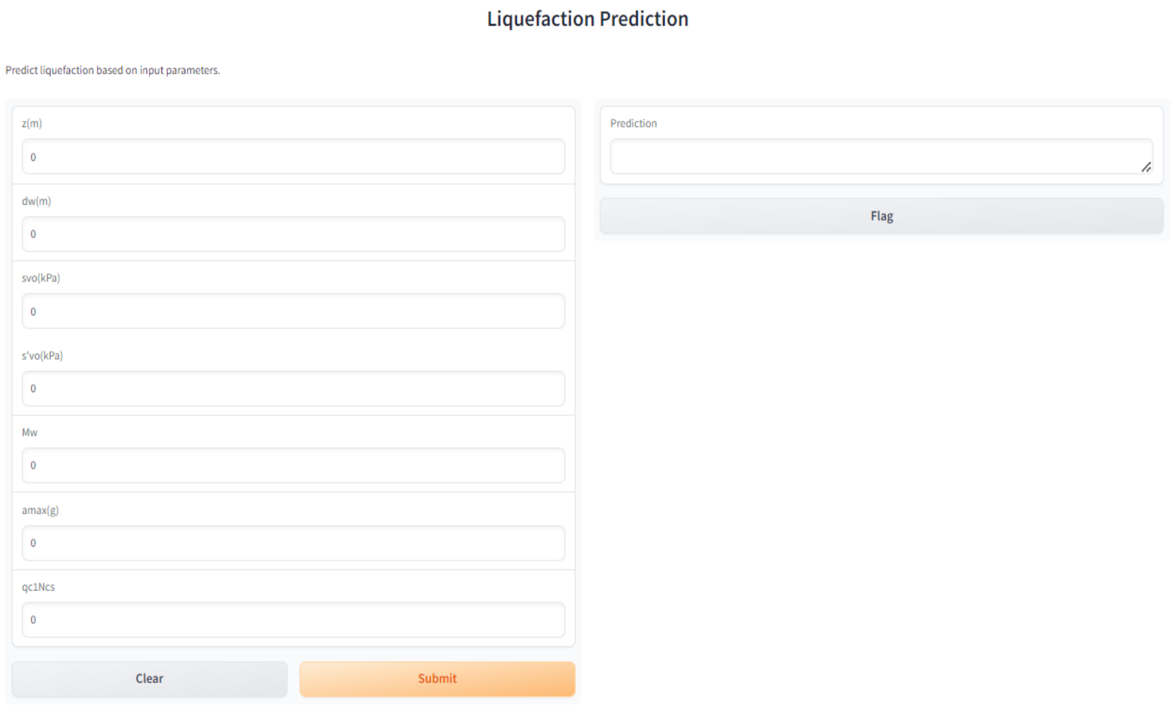

Figure 1 user interface for liquefaction prediction

Conclusion and Futurework

- **1. Enhanced Performance:**
- Refinement and testing phases significantly improved machine learning models for liquefaction susceptibility prediction using CPT data.
- **2. SPT and Vs Models:**
- Deep learning models effectively classify liquefaction potential but show lower accuracy compared to CPT models.
- **3. Future Directions:**
- Focus on exploring alternative algorithms and refining deep learning models for SPT and Vs datasets to enhance predictive accuracy and robustness.

Thank you!

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