Richter's Predictor: Modeling Earthquake Damage*

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Abstract. The aim of this report is to highlights the important criteria from the Richter's Predictor: Modeling Earthquake Damage dataset, that will be used in order to try to predict the damage level of an earthquake.

1 Model Interpretation and Explanation

The aim is to give an explanation and interpretation about the models we have constructed in our earlier classification task. We will start by presenting our best chosen model and trying to go in-depth in order to discover more insightful information and explain them in a more concise manner. Further more, we tried to address a real case study with a personal point of view regarding possible practical use.

1.1 Model Selection - 1 vs Rest Decision Tree Classifier

In order to change our multi-class problem to a binary one and highlights the differences between classes we needed to apply a One vs rest approaches.
We divided our problem into two different sub problems:
1 vs Rest
3 vs Rest
We used the intersection of 1 vs Rest and 3 vs Rest to produce Damage Grade 2.See figure1. After examining the result we obtained from the two different approaches, we observe that the best model is 1 vs Rest. An even in-depth analysis was done to better interpret and evaluate the performance of the two models;The 1 vs Rest model outperforms the 3 vs Rest. Our evaluation metric was the Accuracy and we were able to realised a higher accuracy of 0.75 with the 1 vs rest. Also the Tree we obtain in 1 vs Rest was more interpretable and clearly explain our problem in hand.
After a long and combination of different methods, techniques in our model construction process, we can ascertain that our accuracy is good enough. Thus our 1 vs Rest decision Tree model performs very well

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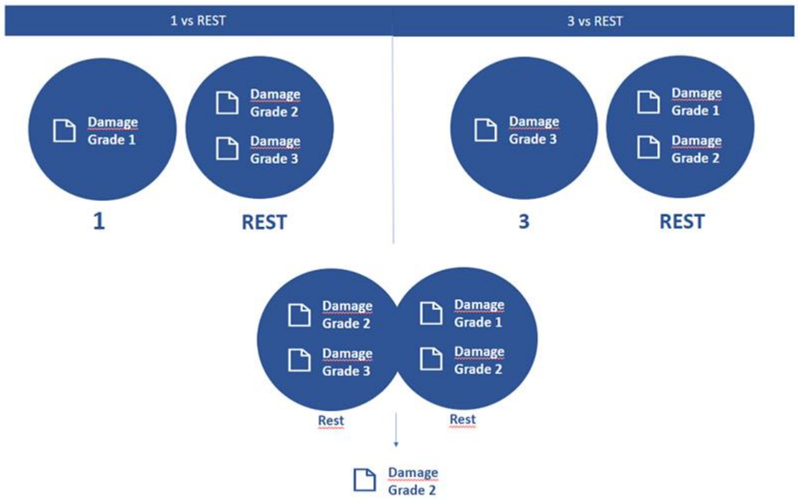

Fig. 1: The two models

1.2 Decision Tree and Features Importance

Looking further to understand the importance of the attributes we considered in our task by using the Tree in our 1 vs Rest Decision tree model. We can visually observe that from the first split in the tree graph which is the **has_superstructure_cement_mortar_stone** has a higher influence in predicting our damage grade properly. The Secondary Use and other variables have a slight impact in our result. See Figure 2

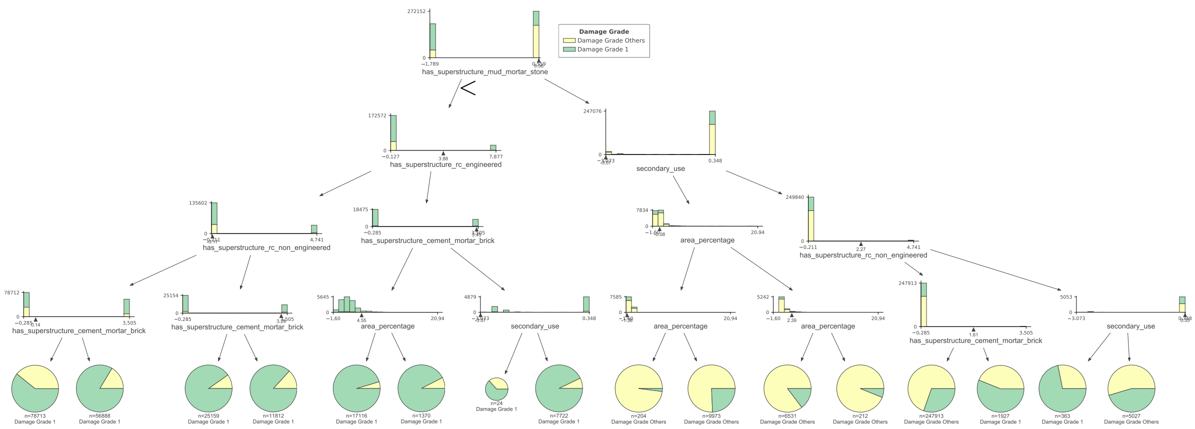

Fig. 2: Decision Tree for Damage Grade 1 vs All

Observing the Graph Tree above, you can visualize that Has Superstructure Mud Mortar Brick, Has Superstructure Rc Engineered and Has Superstructure Rc Not are not far from each other and almost have the same importance. Thus they poorly discriminate our damage Grade class. The remaining two variables which are Secondary Use and Area Percentage where not good at all in predicting our target variable. Thus we can say that they have no useful importance in our classification model. Below is a chronological list of our variable importance, starting from the most important variable to the least important one.See Figure 3

1) Has Superstructure Mud Mortar Stone
2) Has Superstructure Mud Mortar Brick
3) Has Superstructure Rc Engineered
4) Has Superstructure Rc Not Engineered
5) Secondary Use
6) Area Percentage

A graphical representation of our features with there individual accuracy's is given below.

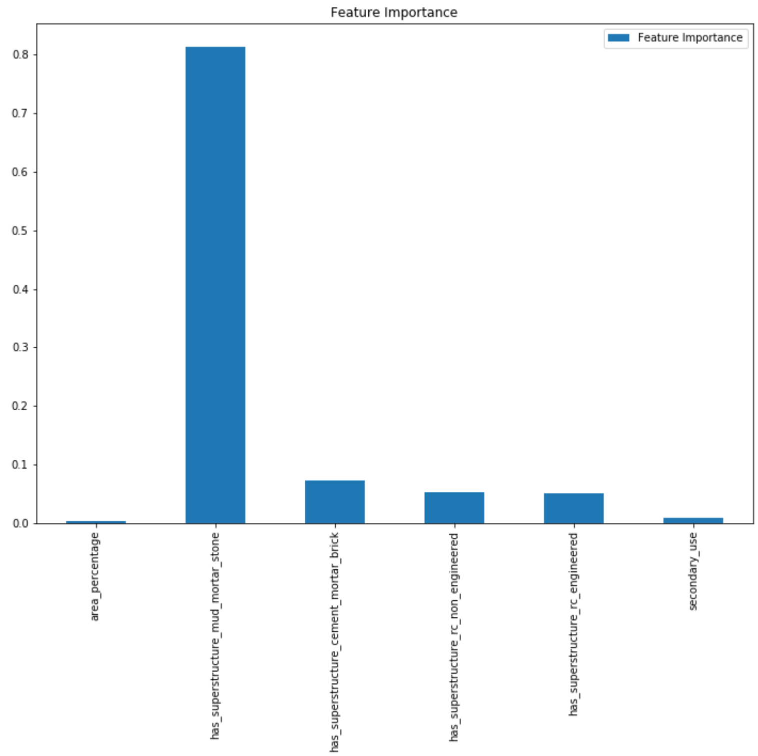

Fig. 3: Features Importance

1.3 Literature confirming our prediction

In theory we cannot fully establish that our model is good with no flaws. To be better sure of the goodness of our model performance, there is need to compare our findings with already completed related work on this topic. These papers also focus there studies on the Gorkha earthquak in nepal. Though they dont perform any machine learning prediction;they used geophysical, physics and architectural concept in analysing their data. a common observation we all have is the low resistant Mud mortar have to earthquakes. We all converge to the conclusion that mud mortar has the highest impact in the event an earthquake happen

"The use of mud mortar is discouraged because of its low resistance to tension caused by seismic forces." [**Mohiuddin AliKhan Ph.D.**, **P.E.**, **C. Eng.**, **M.I.C.E. (London)**, **in Earthquake-Resistant Structures**, **2013**]

"The walls of adobe buildings will crack during moderate to large earthquakes because massive adobe walls activate significant amounts of inertial forces, and both adobe blocks and mud mortar are low-strength materials" [**Mohammad Yekrangnia**, **in Advanced Design Examples of Seismic Retrofit of Structures**, **2019**]

"The residential building typology of Stone in Mud Mortar (SMM) masonry contributed significantly to the seismic losses caused by the 2015 Nepalese seismic sequence" [**2015 Nepal earthquake: seismic performance and post-earthquake**] [**reconstruction of stone in mud mortar masonry buildings**] [**Rohit Kumar Adhikari**]

1.4 Further analysis

A further analysis was done to establish whether our model can make a good prediction by using a different city. Taking New York as a reference, where most building are not constructed using mud mortar stone, our model will not yield a great result. hence features such as Superstructure Rc Engineered, Superstructure Rc non Engineered and so on should be analyse in-depth as it will be more useful in this scenario.

From our Decision Tree the split we know that those features that has a lower damage grade such as secondary use, superstructure engineered are more resistant to earthquake. Therefore looking at New York whose structures are compose of cross braces, supplementary damping,engineered superstructures and so on are highly likely to withstand shocking and shaking movement cause by earthquake.
However, if information about landscape, buildings closeness, street layout and so on might have give us a better understanding. Thus our model could have properly work well in predicting the impact of earthquake in New York.

1.5 Possible reinforcement's

During our research, reading different publications we come by some possible solutions to buildings with risk of high damage when earthquakes occurs. Though is not required by our work but we think is necessary in helping understand how to mitigate the impact level of earthquake. Some of these solutions are:

- Increasing the global capacity (strengthening). This is typically done by the addition of cross braces or new structural walls.
- Reduction of the seismic demand by means of supplementary damping and/or use of base isolation systems
- the local capacity of structural elements. Adopts a more cost-effective approach to selectively upgrade local capacity (deformation/ductility, strength or stiffness) of individual structural components.
- Allowing sliding connections such as passageway bridges to accommodate additional movement between seismically independent structures.

1.6 Personal Real Case Study

In other to make our model to adapt and be able to properly predict regions or cities with different variables to our data-set. we draft these points as possible solution to adapt our model with a new data-set: See figure 4
Get some others dataset with different features
Create a kind of Knowledge Base of Models on Earthquakes
Apply our Knowledge Base to a City with data available
Extract buildings candidate for a possible reinforcement

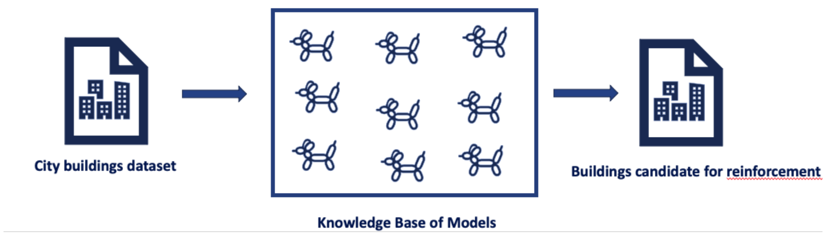

Fig. 4: Personal real case study

1.7 Conclusion

In conclusion we can say that:

- Our 1 vs REST decision tree model is selected with an accurancy of 75
- We extract the most imporant features using decision tree classifier.
- The tree we obtained give us additional in-depth knowledge on our most important features and their behaviours.
- We explore other related work publications that agree on what our model has predicted.
- found a literature review providing ways on improving and reinforcing buildings that can reduce the damage grade in case of future earthquake.
- Finally, we tried to address a real-world case scenario with our proven model.

1.8 REFERENCE

Seismic Performance of Buildings in Nepal After the Gorkha Earthquake, (https://www.researchgate.net/publication/319165939)

Building typologies and failure modes observed in the 2015 Gorkha (Nepal) Earthquake.
Dmytro Dizhur, Rajesh P. Dhakal, Jitendra Bothara and Jason M. Ingham.