Glass Classification Using Artificial Neural Network

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Abstract: As a type of evidence glass can be very useful contact trace material in a wide range of offences including burglaries and robberies, hit-and-run accidents, murders, assaults, ram-raids, criminal damage and thefts of and from motor vehicles. All of that offer the potential for glass fragments to be transferred from anything made of glass which breaks, to whoever or whatever was responsible. Variation in manufacture of glass allows considerable discrimination even with tiny fragments. In this study, we worked glass classification and testing of artificial neural network model created by the JustNN. The aim of the study is help investigator in identifying the type of glass found in arena of the crime. The Neural Network model was trained and validated using the type of glass dataset. The accuracy of model in predicting the type of glass reached 96.7%. Thus neural network is suitable for predicating type of glasses.

Keywords: Neural Networks, type of glass, justnn.

1. INTRODUCTION

Recent studies have indicated that 60% of cases involving glass provided some positive evidence and that in 40% of these cases this evidence was strong. Depending on circumstances, the findings can also refute the allegation that a person was involved in a crime.

For example, when a pane of glass is broken, minute glass fragments can be showered onto the hair, clothing and footwear of people in close proximity – at least 1.5 and possibly up to 3 meters away. The number of fragments transferred decreases rapidly with distance from the breaking pane. Aside from backwards projection of fragments towards the 'breaker', fragments can also be acquired, for example, by climbing through a broken window or treading on pieces of broken glass.

Fragments of glass recovered from hair and clothing are generally in the range 0.25 - 1 millimeter (1mm = 0.039). Most glass is lost fairly rapidly – depending on the activity of the wearer and the texture of their clothing. For example, a woolen jumper will tend to retain glass fragments for far longer than a leather jacket, although fragments can be trapped in pockets, in crevices on shoe uppers and remain embedded in shoe soles for long periods of time.

The results of surveys of the numbers and types of glass fragments found on the clothing of people selected at random shows that it is unusual to find more than a few fragments of glass from the same source on someone's clothing purely by chance.

1.1 How to distinguish different glasses

By and large forensic scientists are interested only in freshly broken glass (clean and sharp-edged fragments) recovered from hair combings or the surfaces of garments, i.e. glass which could have been broken and/or acquired recently. These will be compared and contrasted with reference samples of broken glass, e.g. from the scene, by way of refractive index measurements (a measure of the degree to which the glass bends light) and chemical analysis tests. Refractive Index (RI) is a very accurate test which can distinguish between a large number of different glasses. If the recovered fragments differ in refractive index from a reference glass sample, then they could not have originated from the same piece of glass. Chemical analysis provides detailed information about the chemical constituents of the glass i.e. from the sand and other materials used in its manufacture. Chemical analysis, using, for example, a scanning electron microscope, can be used to distinguish between glass samples which have the same refractive index but different chemical composition.

In addition, the surfaces of glass fragments will be microscopically examined for evidence of the method of manufacture and the type of object from which they came, for example, flat glass and patterned glass (both from window panes) or curved glass (drinking glass or bottle). Further tests may be performed to see if the source was of toughened glass (forming small cubes when broken and typically found in some car windows and in door and window glazing).

1.2 Interpreting what's found

If the recovered fragments match the reference sample both in RI and chemical composition it is necessary then to discover how rare or otherwise the glass might be. To do this the scientist may consult a computer database containing the combined results of the RI measurements and the chemical analysts results for each and every reference glass sample examined by his lab. This will show how many times a particular type of glass has been encountered, but this is not necessarily a reliable indication of how common it might be. This is because most glass samples submitted to forensic laboratories are from broken windows, although research has shown that glass found on clothing by chance is more likely to have originated from a container (such as a glass or a bottle). Aside from this, there tend to be local pockets of specific types of glass, e.g. from buildings all built at the same time. All this means that information held on the database might be skewed and should be treated with caution.

Aside from databases, the forensic scientist will also need to consider for example, the number and distribution of the glass fragments he has recovered and whether this fits in with the alleged circumstances.

The finding of numerous fragments of glass on a suspect detained within a few hours of windows being broken may be very strong evidence, for example if the glass is unusual and/or there is more than one type of matching glass. On the other hand, less weight would be given to the presence of one or two fragments of a common type of glass found on clothing seized several days after an incident.

Finally, it is often suggested that fragments might be transferred between people who come into contact after the crime has been committed, for example when they travelled side-by-side in a police vehicle. Whilst in theory this is quite conceivable, the results of tests show that only one or two fragments at most are likely to be transferred in this way and only a few remain on the seat occupied by the contaminated person.

We can help forensic scientists in distinguishing between different types of glass using an easier way, Artificial Neural Network. Artificial Neural network is getting popular now-adays due to its capability of generalization and resistance to the noisy and erroneous data. A lot of research is undergoing to improve the efficiency and accuracy of the modeling and training of the neural network architecture. Although lot of research work has been done but still there is no profound theory about the exact number of size of the data, architecture of the network and the best suitable algorithm for the ANN modeling because selection of these parameters depends on the nature of the data.

1. NEURAL NETWORK

Neural Network is the biological structure inspired by the working of human nervous system. Neural Network is being applied widely on different application areas due to its learning ability i.e. capability to extract rules and learn from the data and create a network model which can be used for classification, pattern recognition and forecasting on the data. Most promising feature of the Neural network that other classification techniques do not possess is that it helps to simulate the network and create model which can be used further and applied on the new data which was not previously exposed to the network.

JustNN is a tool which is used for Neural Network modeling. JNN tool helps in creating a neural network model to train and validate the data for classification of the data, find hidden patterns, clustering and future forecasting.

2. GLASS DATASET: CASE STUDY

We have used glass dataset for classification because it can prove to be very useful in crime investigation, behavior of glass material etc. The small pieces of glasses obtained from the crime sites can be very crucial evidence for the investigation purpose. We can create a neural network model and train it on glass data which can further help us to classify the unknown type of glass which was previously not exposed to the model. There are 2014 instances in the glass dataset with 10 input attributes and 1 output attribute (Type of glass).

Attribute Information: (Input attributes)

Id number
 RI: refractive index
 Na: Sodium
 Mg: Magnesium
 Al: Aluminum
 Si: Silicon
 K: Potassium
 Ca: Calcium
 Ba: Barium
 Fe: Iron

Type of glass: (output attributes)

- 1. Building_windows_float_processed
- 2. Building_windows_non_float_processed
- 3. Vehicle_windows_float_processed
- 4. Vehicle_windows_non_float_processed
- 5. Containers
- 6. Tableware
- 7. Headlamps

Details of the input and output attributes are explained above. Type of glass will depend on the values of the input attributes and by these values network will be trained and tested to classify that the record will lie in which Type of Glass. In Table 1, sample dataset has been displayed.

Table (1): Sample data of the actual glass dataset

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ld number	RI	Na	Mg	AI	Si	к	Са	Ва	Fe	Type of glass
1	1.52101	13.64	4.49	1.1	71.78	0.06	8.75	0	0	1
2	1.51761	13.89	3.6	1.36	72.73	0.48	7.83	0	0	1
3	1.51618	13.53	3.55	1.54	72.99	0.39	7.78	0	0	1
4	1.51766	13.21	3.69	1.29	72.61	0.57	8.22	0	0	1
5	1.51742	13.27	3.62	1.24	73.08	0.55	8.07	0	0	1
6	1.51596	12.79	3.61	1.62	72.97	0.64	8.07	0	0.26	1
7	1.51743	13.3	3.6	1.14	73.09	0.58	8.17	0	0	1
8	1.51756	13.15	3.61	1.05	73.24	0.57	8.24	0	0	1
9	1.51918	14.04	3.58	1.37	72.08	0.56	8.3	0	0	1
10	1.51755	13	3.6	1.36	72.99	0.57	8.4	0	0.11	1

3. EXPERIMENTATION

Experiment was performed on the JNN Tool with the glass dataset as explained above. In this experiment that dataset consists of 214 samples. We divided the dataset to 154 training samples and 60 validation samples. We have created the neural network model by the help of the JNN associated with the layers of the network and analyzed its effect on the classification of the type of glass and the average error obtained in the results. The ANN network model consists of input layer with 10 neurons, 3 hidden layers (7 x 1 x 1) neurons and 1 output layer with one neuron.

Figure 1: and Figure 2: are the screen shots taken from the JNN Tool. Figure 1: shows the neural network model created for glass data classification. This figure describes the architecture of the model created and how input parameters are connected to hidden layers and further hidden layers are connected to output layer. Figure 2: Neural Network input importance which is the sum of the absolute weights of the connections from the input node to all the nodes in the first hidden layer.



Figure (1): Neural Network input importance.

Type of glasst	Net input	500	Negative Weight		
	Activation		Basitiva Walnut		
	Bias	0.000	Langue Heiline		
	Error		Insignificant Weight		



Figure (2): Neural Network Model created by JNN.

We first normalized the dataset then uploaded it in JNN environment. We chose the number of hidden layers, divided the dataset to training and validating samples as discussed above. We trained and validated the ANN Model until we got accuracy 96.70%. The average error was 0.0153. The number of epochs is 12032. The evaluation of the ANN model is shown in Figure 3.



Figure (3): Neural network learning chart

4. CONCLUSION

- By the above results obtained we have observed that:
- It has been found that as the number of times we train our network model the average error decreases as observed from the results obtained from figure 3.But overtraining may also lead to increase in error.
- ANN is suitable for glass type classification
- The accuracy was 96.7% which promising percentage for glass type classifications.

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