A COHORT STUDY ON OXIDATIVE STRESS INDICATIONS IN CHILDREN EXPOSED TO CELL PHONE AND CELL TOWER RADIATION

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Abstract- This study investigates oxidative stress in children exposed to cell phone and cell tower radiation by developing a predictive model for Superoxide Dismutase (SOD) activity by analyzing key parameter radiation exposure levels and fibrinogen concentration to predict SOD activity. A neural network model with polynomial feature transformation was implemented to capture non-linear relationships between exposure and oxidative stress markers. The model achieved an R^2 of 0.0995, with mean absolute error (MAE) of 0.8397, mean squared error (MSE) of 0.9909, and root mean squared error (RMSE) of 0.9955.

Index Terms- Neural Network Model, Superoxide Dismutase(SOD), Fibrinogen Concentration, Oxidative Sress.

I. INTRODUCTION

Oxidative stress is a condition that occurs when the body has too many free radicals and not enough antioxidants to neutralize them. In recent years children are highly addicted to cell phones and exposed to cell towers radiation. These cell towers causes Electromagnetic radiation among children. These radiation affects the children health and mind. So this paper is all about the oxidative stress indications in children exposed to cell phone and cell tower radiation using the Superoxide Dismutase (SOD) as biomarkers. Radiation exposure levels and fibrinogen concentration as it's parameter.

II. METHODOLOGY

We have used parameters, including radiation and fibrinogen, in our study. Radiation refers to the energy emitted as electromagnetic waves or particles. Types include ionizing (e.g., X-rays, gamma rays) and non-ionizing (e.g., UV, microwaves) radiation. Ionizing radiation, in particular, has enough energy to remove tightly bound electrons from atoms, creating ions. This ionization can lead to the formation of free radicals within cells, which are highly reactive and can damage cellular components, including DNA, lipids, and proteins. Such damage is directly linked to oxidative stress.
Radiation exposure generates free radicals, specifically reactive oxygen species (ROS), that overwhelm the cell's antioxidant defenses, leading to oxidative stress. This stress triggers the upregulation of antioxidant enzymes like SOD as part of the body's defensive response to neutralize ROS.

Fibrinogen is a blood plasma protein primarily involved in clotting. When tissue damage occurs, fibrinogen is converted to fibrin, which helps form a clot to stop bleeding. However, fibrinogen also plays roles in inflammation and as a biomarker for various diseases. Inflammation, often associated with increased fibrinogen levels, is a known contributor to oxidative stress. Elevated fibrinogen can indicate a heightened inflammatory state, which increases ROS production and places greater demand on antioxidant defenses like SOD.
The radiation exposure can increase fibrinogen levels as part of the body's inflammatory response. Thus, individuals exposed to high radiation levels might also exhibit increased fibrinogen, further linking the two factors to oxidative stress.

SOD is an enzyme that catalyzes the breakdown of superoxide radicals, a type of ROS, into oxygen and hydrogen peroxide. This process is crucial in reducing oxidative stress within cells.
High radiation exposure and elevated fibrinogen levels both elevate oxidative stress. SOD activity can be upregulated as a protective response to such stressors. An increase in SOD activity indicates the body's attempt to manage excessive ROS. However, if oxidative stress continues unchecked, even elevated SOD levels may not be sufficient, leading to cellular and tissue damage.is crucial in reducing oxidative stress within cells.

Figure 1: Distribution of various features in the dataset

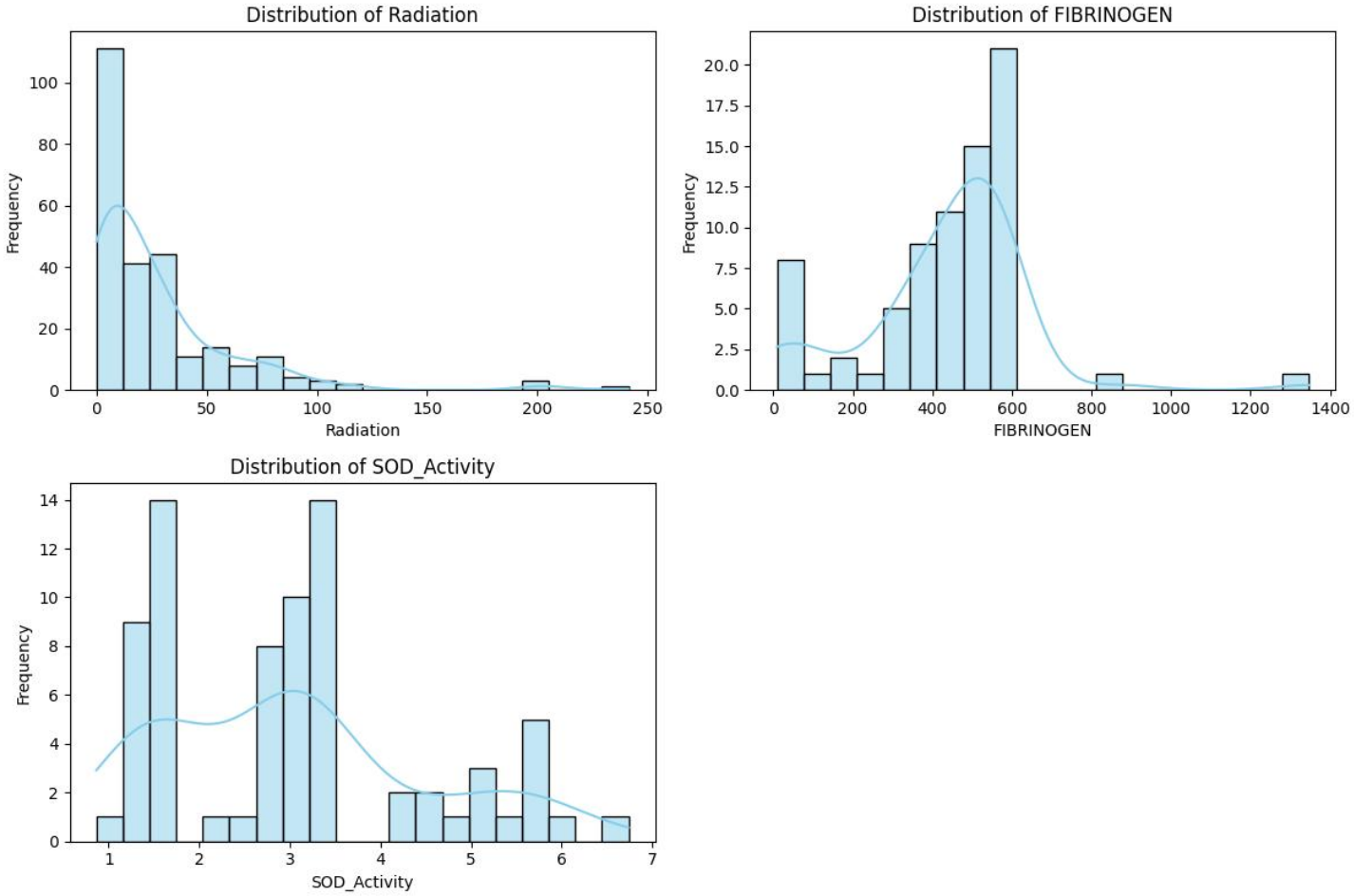


Table 1: Description of Features

S.No	Attribute	Description	Values
1	Radiation	The level of radiation exposure experienced by the subject.	Numeric values, typically continuous (e.g., 0 to 1000)
2	Fibrinogen	The concentration of fibrinogen, a plasma protein involved in clotting. High levels may indicate inflammation or cardiovascular risk.	Numeric values (e.g., 100 to 700 mg/dL)
3	SOD_Activity	Superoxide Dismutase (SOD) enzyme activity, which plays a key role in reducing oxidative stress by neutralizing free radicals.	Numeric values (e.g., 0 to 100 U/mg of protein)

III. IMPLEMENTATION

Data collection:

Data is collected from various people who were kept under observation with continuous monitoring.There are three parameters under consideration i.e Radiation,SOD_activity and Fibrinogen

Replacing and dropping missing values:

Before training and testing the model the missing values in columns like Radiation,SOD_activity and Fibrinogen were replaced and dropped using replace and dropna method.

Convert columns to float for analysis:

The columns in the dataset are converted to float datatype so that it ensures the values in the column are in numerical format so that gives better analysis for training the model.

Input and target variables:

Here Radiation and Fibrinogen as input variable, SOD_activity is considered as target variable.

Polynomial transformation:

The relationship between these columns is nonlinear so polynomial transformation should be applied.

Scale Standardizing:

Standardize the given data to check input features are on similar scale and was applied to polynomial features to ensure they have mean of 0 and standard deviation of 1.

Splitting the data into Training and testing test:

Here 80% of data is considered for training the data and 20% of data is considered for testing the data

Neural network Architecture:

Build a neural network model which consists of three layers i.e. input layer, hidden layers and output layer. There is one Input layer which accepts vectors of factors, There are multiple hidden layers, first hidden layer has 64 neurons along with relu activation function, second hidden layer has 34 neurons along with activation function.relu activation function is used in neural network because it allows the network to learn complex patterns. There is one output layer which has one neuron and no activation function and represents the predicted SOD activity

Compile the model:

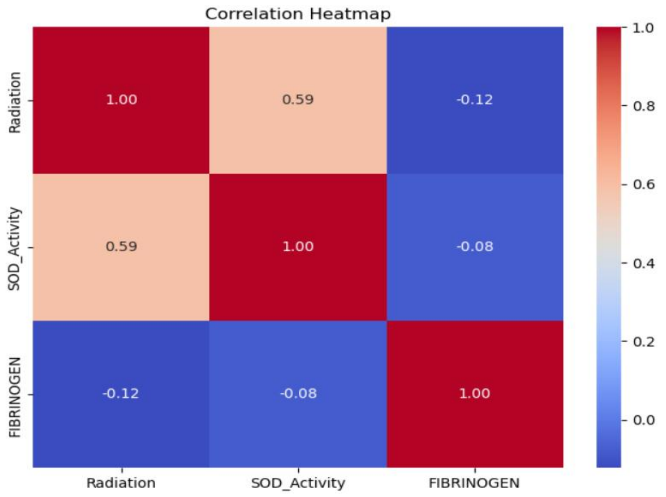
Mean Squared Error is used as a loss function and adam optimiser is used.

Model training:

Model is trained for 100 epochs so that it passes through the entire dataset 100 times and batch size of 10 was selected and that for each epoch, the model updates weights after every 10 samples and set the SOD_threshold to 3.5

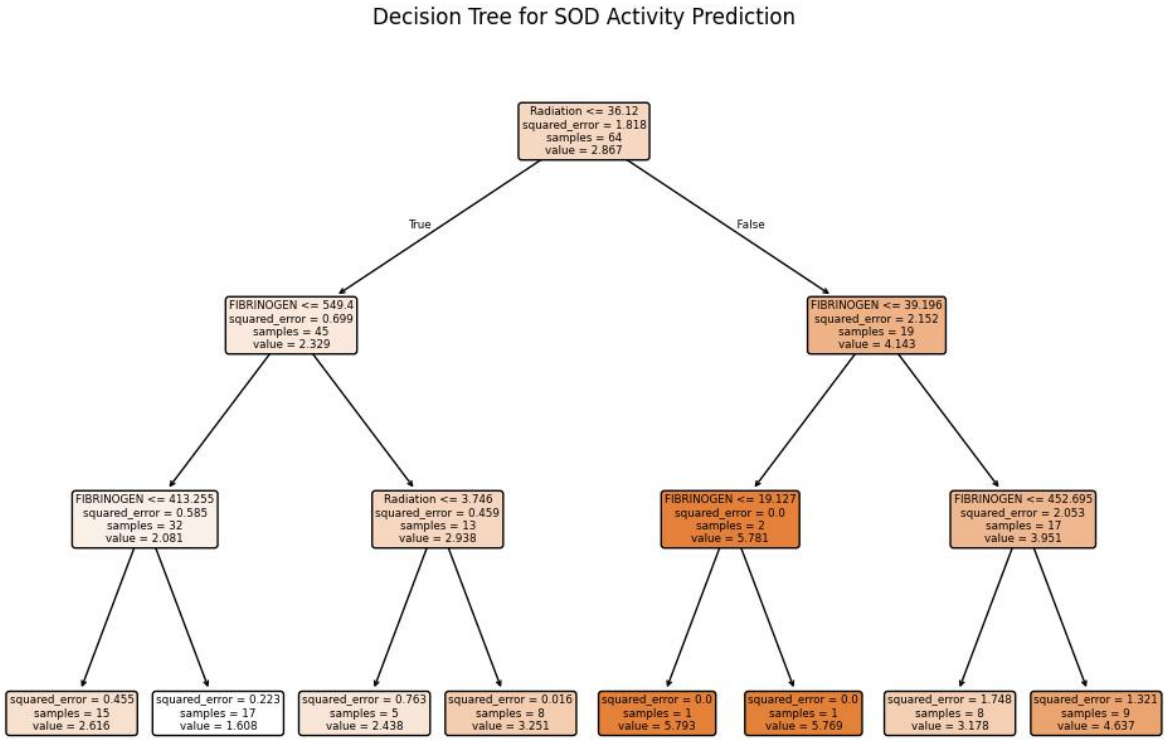
IV. RESULT

Correlation Heatmap:



Displays the relationship between three variables Radiation,SOD_activity and fibrinogen. There is positive correlation of 0.59 between radiation and SOD_activity, so if radiation activity increases SOD_activity will also increase. There is a negative correlation of –0.12 between radiation and fibrinogen so if radiation increases there will be decrease in fibrinogen level. There is a week correlation of –0.08 between SOD_activity and fibrinogen. Diagonal values represent correlation itself is always 1

Plotting of Decision tree:



There are three nodes root node, internal node and leaf node.
The decision tree starts with a Radiation <= 36.12. Total number of samples is 64 and value is 2.87.The internal node represents either fibrinogen and radiation that further splits the data based on the predicted value. Leaf nodes are terminal nodes where no further splitting occurs. Each leaf node provides a final prediction.Each node shows squared error,values and samples

Graph for training and validation loss over epochs:

The graph represents training and validation loss. The blue line represents training loss graph .It starts high and then decreases as the model learns The orange line represents validation loss which is not used for training. Initially, it decreases quickly. Around the 20th epoch, it fluctuates but remains close to the training loss, indicating that the model is not overfitting.

Model evaluation:

Calculate the model's performance using the metrices, Mean Absolute Error (MAE) Mean Square Error(MSE),Root Mean Square Error(RMSE),R squared (R^2)

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 50ms/step
Model Performance for SOD Prediction:
Mean Absolute Error (MAE): 0.8874
Mean Squared Error (MSE): 1.0979
Root Mean Squared Error (RMSE): 1.0478
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Calculating model performance using MAE,MSE,RMSE

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CLASSIFICATION REPORT

Testing Accuracy: 84.62%

Classification Report for Test Set:
                  precision    recall    f1-score    support

 Not Exposed       1.00         0.82       0.90         11
     Exposed       0.50         1.00       0.67          2

    accuracy                              0.85         13
   macro avg       0.75         0.91       0.78         13
weighted avg       0.92         0.85       0.86         13

1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 16ms/step
Validation Accuracy: 84.62%
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The model has 84.62% testing accuracy and validation accuracy. Classification report shows details about precision, recall,f1 score and support for each class.

Function to classify oxidative stress based on user input:

Input 1:

Prepare the input data with polynomial transformation and scaling.Classify based on threshold.As we have considered Radiation and Fibrinogen as input vairable so get user input for Radiation and Fibrinogen and use the function to classify oxidative stress based on user input and plot the graph between User's SOD Activity Prediction and Oxidative Stress Threshold

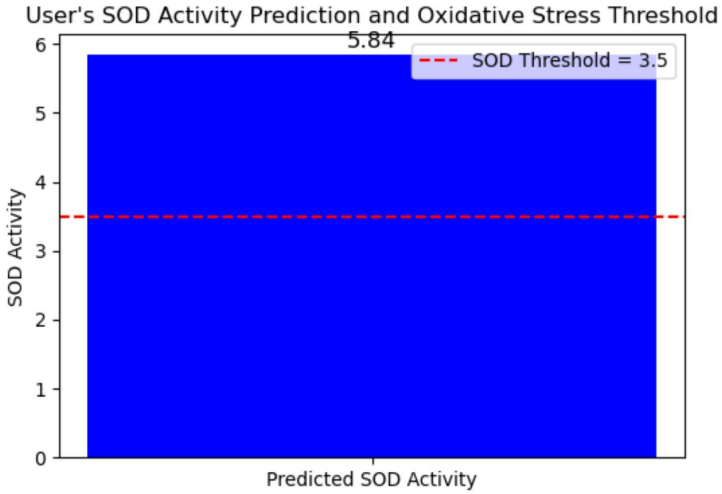


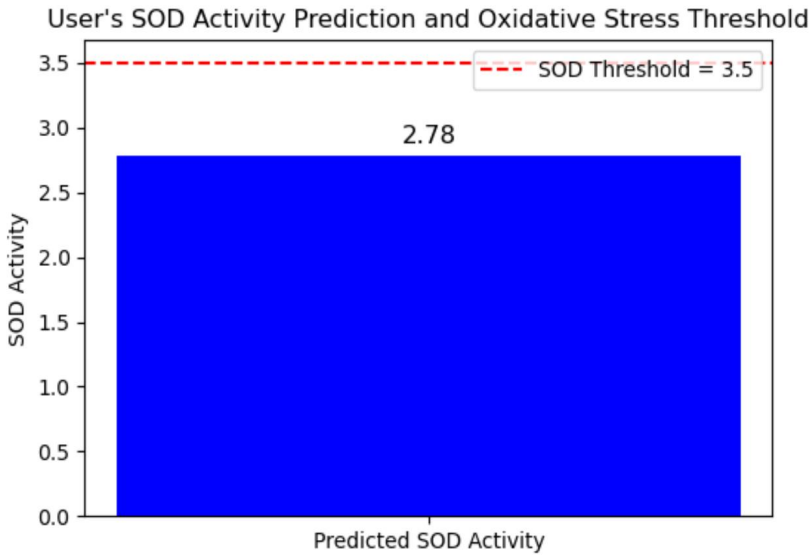
Figure (a)

```
Enter Radiation level for prediction:  100
Enter Fibrinogen level for prediction:  20
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 49ms/step

Predicted SOD Activity: 5.84
Exposure    Status:    Exposed    to    Oxidative
StressThreshold for Oxidative Stress (SOD): 3.5
```

Figure (a) tells when the new input is exposed to oxidative stress.X axis represents SOD_activity and Y axis represents Predicted SOD_activity .If the predicted SOD_activity of the given input is higher than the threshold SOD then the exposure status will be "Exposed to Oxidative stress".
In this case Predicted SOD is 5.84 and SOD threshold is 3.5 so predicted SOD hence exposure status will be "Exposed to Oxidative stress".

Input 2:




```
Enter Radiation level for prediction:  20
Enter Fibrinogen level for prediction:  20
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 45ms/step

Predicted SOD Activity: 2.78
Exposure Status: Not Exposed to Oxidative
Stress
Threshold for Oxidative Stress (SOD): 3.5
```

Figure (b)

Figure (b) shows when the new input is not exposed to oxidative stress.X axis represents SOD_activity and Y axis represents Predicted SOD_activity of the predicted SOD_activity.If the given input is lower than the threshold SOD then the exposure status will be "Not Exposed to Oxidative stress"
In this case Predicted SOD is 2.78 and SOD threshold is 3.5 so predicted SOD hence exposure status will be "Exposed to Oxidative stress".

V. Conclusion

This model aims to create an accurate model that can predict SOD activity and assessing oxidative stress in children exposed to radiation. The use of neural networks, combined with polynomial features , allows for a robust and flexible approach to a biologically complex problem.

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