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Human Centric Computing Applications for Laptop Price Prediction

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***Abstract*--With the rapid enhancement of modern technology, we are more engaged with online shopping due to its high comfort, ease to use, safety etc. So we find a problem for laptop product evaluation in the online as well as offline market. The demand for laptops were rapidly increased after the lockdown in India. In the June quarter of 2021, 4.1 million units were shipped and which is the highest shipment in five years. In laptops, the price is acquired from its RAM, ROM, CPU, GPU, Touch screen, model, trends etc. Sometimes it is very much difficult for the customer as well as the retailer to fix a price with the certain characteristics of laptops so that both can evaluate the price and be satisfied with it. So we are going to develop a model for predicting the laptop price as per its properties. Because of any casual customer, this model will help in selecting and deciding on a laptop whether to buy or not, and also will reduce the time and effort that anyone will have to spend manually researching the market price. This paper will focus on Human-centric computing applications for laptop price prediction because it can be analyzed by those well-structured data that itself enhanced machine learning techniques, easily representable as a set of qualified parameters etc. So, we will develop an attribute-based prediction model for laptops using Regression machine learning algorithm.**

***Keywords*-- Collaborative, Data Mining; Human-Centric-Computing, Data Science.**

I. INTRODUCTION

IN modern society, there is an increasing demand for laptops as per their functionalities in our social life. Due to 'workfrom home' and 'learn from home', laptop shopping has rapidly increased after the worldwide lockdown [23]. Laptop price prediction is very difficult but important when it comesdirectly from the factory. We have taken the evaluation part of the laptop for online as well as the offline market. It can reduce human effort and involvement by making this model available for the reseller as well as the user.

We predict the price prediction based on our certain experience or limitedknowledge so there is a limitation to it [1] [6]. For any normal buyer, it is not possible to manually observe the market for the whole price scenario for each laptop as per its model. So this model will provide a way for analyzing the market as per any customer's requirements. We have faced a different type of pricing problem in online shopping like there are different types of laptop but pricing is not concluded as per its properties, regret the selected option, and cannot compare the small details of different models which make the price mode effective, doubtful about the product idea for the best option, takes lots time of match our requirement etc. From that situation, we are stuck or irritate so badly to take the right decision for the right one. As per the retailer side, price is one of the challenges to fix for the laptop. So, this laptop price prediction model will help us to overcome these headaches [3]
[9] [11]. As per Psychology, human capacity is limited from five to nine alternatives parallel comparison [5] [7] [8] [15]. Human-centric enhancement helps us to involve in modern society.

Pricing of any laptop is a science as well as an art that needs different types of experimental and statistical observation to generate a profile for the brand and the product in the market. In 2017, the "How Humans Are Shaping Their Own Evolution" magazine tells us how we are interconnected with modern society [12].

There are several models already exist i.e. SVM, mean model, DT, random forest etc. for predicting the laptop price but still some problems occur. These models have faced some linearity problems that means assuming the relationship between the input features and output variable is linear. However, in real-world scenarios, the relationship may be non-linear. Decision tree and random forest models can be prone to overfitting, where the model fits the training data too closely and performs poorly on new, unseen data. These models are not able to remove the irrelevant features which reduce the accuracy. So, Regression models, such as polynomial regression, can capture non-linear relationships between the input features and the output variable. It can prevent overfitting and improve the model's generalization performance using Ridge and Lasso regression. It also provides the more interpretable results than previous classical algorithms. It improves the accuracy level by allowing only

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relevant features to be included in the model.

Our proposed model is divided into two parts i.e. statistical model and the machine learning model. There are different types of aspects affecting the laptop price like Random access memory, Read-only memory, CPU, Graphical Processing Unit(GPU), model, display touchscreen etc. [4]. Visual features also play a vital role in affecting the cost and it is the most important factor for the decision-making of any buyer [2] [3] [10] [18] [22] [25]. Generally, it imposes a certain picture ofthe production classically.

II. LITERATURE SURVEY

Machine learning algorithms have emerged as a powerful tool for solving accurately predicting laptop price prediction. It is a complex relationship between laptop features and price.

The [14] paper provides different machine learning algorithms like: regression-based models, decision tree and neural network for laptop price prediction. It includes the feature selection and dimensionality reduction techniques to improve the accuracy level.

The [24] paper mainly compares the different machine learning algorithms such as linear regression, KNN, SVM etc. To improve the quality of the input data, it uses the data pre-processing techniques.

The [16] and [17] papers also contain different machine learning techniques for laptop price prediction and include the feature engineering techniques used to select relevant features and reduce the dimensionality of input data.

The [26] paper provides an overview of the different machine learning algorithms i.e. SVM, decision tree, artificial neural network etc. for laptop price prediction. It also talks about training and testing dataset and looks after the potential challenges and limitations in laptop price prediction using machine learning.

The [19] and [21] paper includes the comparisons the performance of different machine learning algorithms. It also talks about the feature engineering techniques like: normalization, outlier and feature selection for laptop price prediction.

The [20] paper also provides an overview of the different machine learning techniques and algorithms for laptop price prediction containing gradient boosting, decision tree and artificial neural networks etc. It also talks about the evaluation metrics for the comparisons of these models like: mean squared error, root mean square error and coefficient of determination.

From the analysis, we have observed that there are different types of regression models such as linear regression, polynomial regression and ridge regression. Linear regression is the most basic regression model and also involves fitting a straight line to the data for representing the relationship between the input features and the output variable. Besides, the polynomial regression can fit a curve to the data, which captures more complex relationships between the features and the price. Ridge regression is a type of regression that can help to prevent overfitting by adding a cost function which makes it as a penalty. By this way, we can reduce the impact of less important features in predicting the price of a laptop.

III. METHODOLOGY

We have proposed a model which tries to make a bridge to reduce the gap of standard econometric method and machine learning by using the previous data. It makes a pattern from the huge data using the data mining technique to predict the price of any laptop. With the enhancement of technologies, the decision making of any laptop becomes more complex due to its different characteristics. As per the human knowledge, the decision making is too much narrow for identifying the complexity [8]. We have faced two major problems in the collaborative methods:

i. Difficult for the customer for recognize the certain properties due to redefined product features.
ii. Huge previous data due to frequently technological enhancement.

Our model can solve these problems as well as reduce the gap of estimated price and real price of laptop. From fig.1, we can analyze the flow of design and analyze the prediction model.

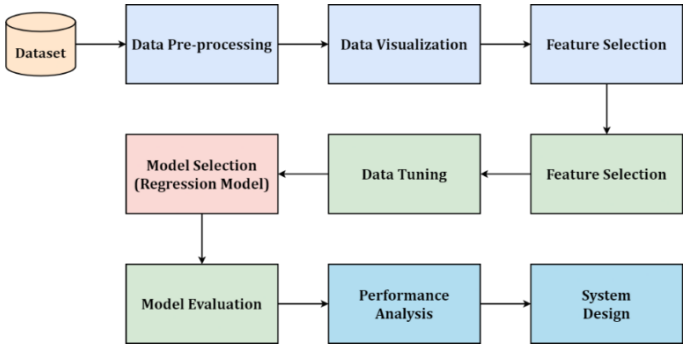

Fig. 1. Flow of design and analysis

There are few steps to make the laptop price prediction model from the given dataset i.e.

I. **Data Pre-processing.** In this model, we have used a dataset from the kaggle.com [13] which contains 1303 rows as laptops and 12 columns as features. Here, we have to pre-process the dataset first to remove the noisy data. From the Fig.2, we can see that 'weight' and 'Ram' are the useful data so we have to convert it into

	Unnamed: 0	Company	TypeName	Inches	ScreenResolution	Cpu	Ram	Memory	Gpu	OpSys	Weight	Price
0	0	Apple	Ultrabook	13.3	IPS Panel Retina Display 2560x1600	Intel Core i5 2.3GHz	8GB	128GB SSD	Intel Iris Plus Graphics 640	macOS	1.37kg	71378.6832
1	1	Apple	Ultrabook	13.3	1440x900	Intel Core i5 1.8GHz	8GB	128GB Flash Storage	Intel HD Graphics 6000	macOS	1.34kg	47895.5232
2	2	HP	Notebook	15.6	Full HD 1920x1080	Intel Core i5 7200U 2.5GHz	8GB	256GB SSD	Intel HD Graphics 620	No OS	1.86kg	30636.0000
3	3	Apple	Ultrabook	15.4	IPS Panel Retina Display 2880x1800	Intel Core i7 2.7GHz	16GB	512GB SSD	AMD Radeon Pro 455	macOS	1.83kg	135195.3360
4	4	Apple	Ultrabook	13.3	IPS Panel Retina Display 2560x1600	Intel Core i5 3.1GHz	8GB	256GB SSD	Intel Iris Plus Graphics 650	macOS	1.37kg	96095.8080

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Fig. 2. Dataset for Laptop Price

II. Exploratory data Analysis. By using the 'seaborn' library, we can analyse the data very efficiently. From the Fig.3, we can visualize the number of laptops as per its price.

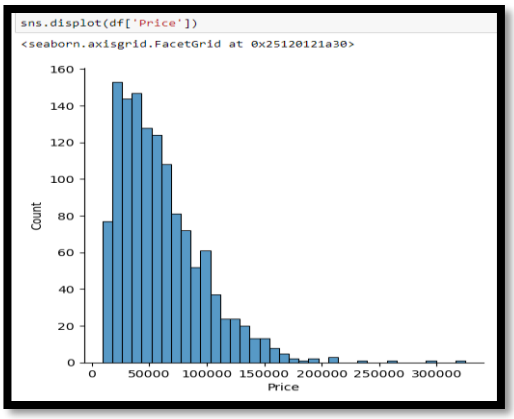

Fig. 3. Number of Laptop with respect to Price

The brand of the laptop is another factor for pricing any product. We very much aware that how the brands can differentiate the price from the Fig.4.

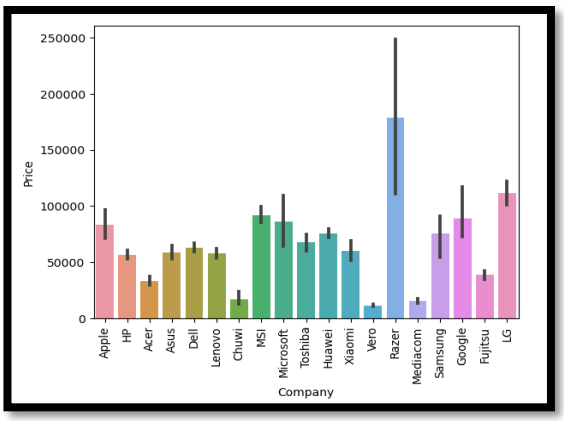

Fig. 4. Price vs Company

From the Fig.5, we can analyze the laptops which are used by the used. In that case, notebook uses the most for its convenient and efficiency. From the other hand Fig.6, we can see the price of the laptop as per its type. In that care, 'Workstation' contains the highest and 'Netbook' contains the lowest price as per the given dataset.

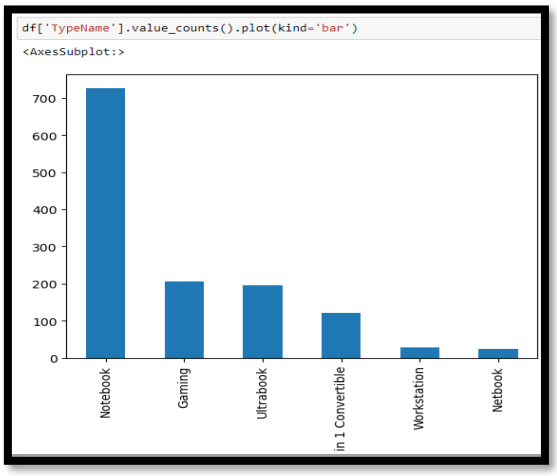

Fig. 5. Types of laptops people refer

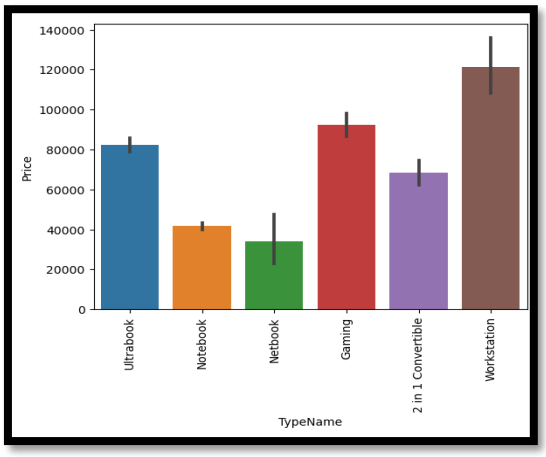

Fig. 6. Variation of laptop type with price

III. Feature Engineering. In this step, we have to extract the useful features from the dataset. As an example, From Fig.7, we have extracted the Touchscreen information from the dataset i.e. touchscreen is available or not. So, we can see that the laptop with touchscreen is more expensive than non-touchscreen laptop.

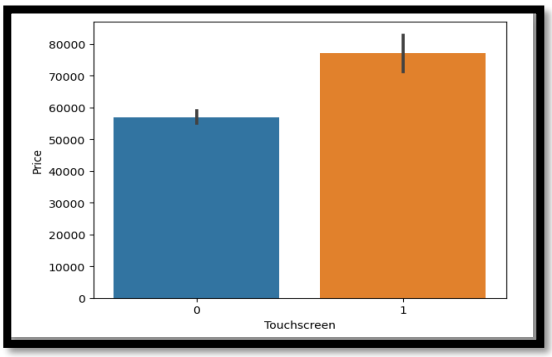

Fig. 7. Touchscreen and Non-Touchscreen against Price

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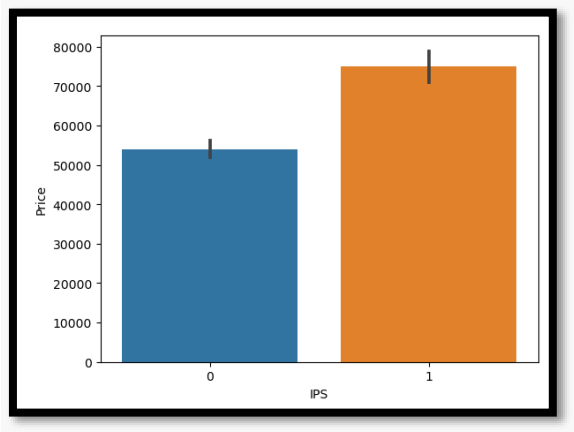

Fig. 8. IPS and Non-IPS against Price.

Beside, we can also notice the Fig.8 that the price of the laptops with IPS is more than the non-IPS laptops. So, we have calculated the 'ppi' using the different parameters in Fig.9.

	Company	TypeName	Ram	Weight	Price	Touchscreen	IPS	ppi	Cpu brand	HDD	SSD	Gpu brand	os
0	Apple	Ultrabook	8	1.37	71378.6832	0	1	226.983005	Intel Core i5	0	128	Intel	Mac
1	Apple	Ultrabook	8	1.34	47895.5232	0	0	127.677940	Intel Core i5	0	0	Intel	Mac
2	HP	Notebook	8	1.86	30636.0000	0	0	141.211998	Intel Core i5	0	256	Intel	Others/No OS/Linux
3	Apple	Ultrabook	16	1.83	135195.3360	0	1	220.534624	Intel Core i7	0	512	AMD	Mac
4	Apple	Ultrabook	8	1.37	96095.8080	0	1	226.983005	Intel Core i5	0	256	Intel	Mac
...	...	...	...	...	...	...	...	...	...	...	...	...	...

Fig. 9. Resultant dataset

As we know the CPU and GPU of any laptop are playing the vital role for impacting the price. To get the CPU data, we have to extract Intel and Advance Micro Device (AMD) pre-processor. So, there 5 types of dataset available in the 'CPU' column i.e. i3, i5, i7, other Intel processors and AMD processors. From the Fig.10, the price of i7 processor laptop is much higher than the others (i5 > i3 ≈ AMD ≈ other Intel processors). From fig.11, we can analyze the price of 'Nvidia' is much higher than Intel and the price of Intel is higher than AMD (Nvidia > Intel >AMD).

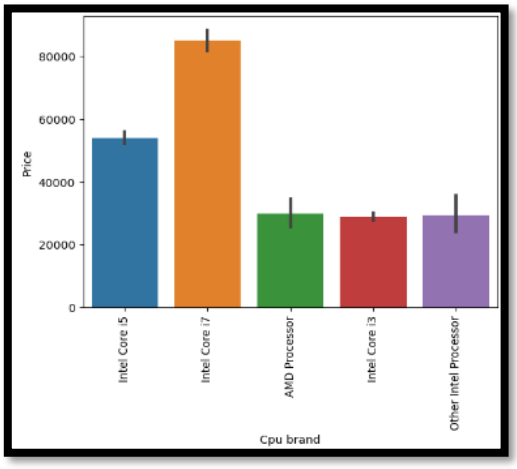

Fig. 10. CPU vs Price

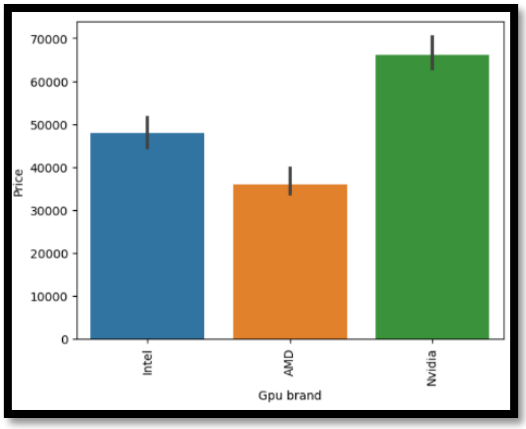

Fig. 11. GPU vs Price

The variation of operating system is also a factor for affecting price. From fig.12, we clearly analyze that it plays an important role for price of laptop.

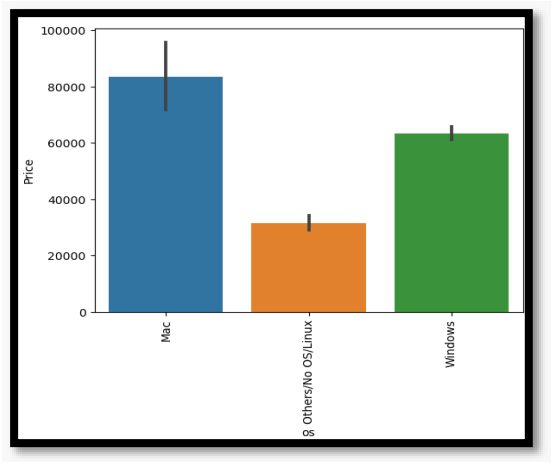

Fig. 12. Operating system Price

After pre-processing the dataset, we will get the final datasetfig.13.

	Company	TypeName	Ram	Weight	Price	Touchscreen	IPS	ppi	Cpu brand	HDD	SSD	Gpu brand	os
0	Apple	Ultrabook	8	1.37	71378.6832	0	1	226.983005	Intel Core i5	0	128	Intel	Mac
1	Apple	Ultrabook	8	1.34	47895.5232	0	0	127.677940	Intel Core i5	0	0	Intel	Mac
2	HP	Notebook	8	1.86	30636.0000	0	0	141.211998	Intel Core i5	0	256	Intel	Others/No OS/Linux
3	Apple	Ultrabook	16	1.83	135195.3360	0	1	220.534624	Intel Core i7	0	512	AMD	Mac
4	Apple	Ultrabook	8	1.37	96095.8080	0	1	226.983005	Intel Core i5	0	256	Intel	Mac
...	...	...	...	...	...	...	...	...	...	...	...	...	...

Fig. 13. Final dataset

We can analyze the correlation matrix (fig.14) from the given dataset,

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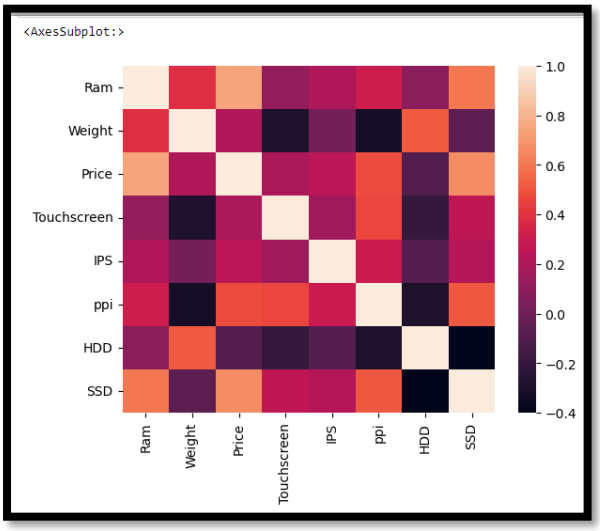

Fig. 14. Correlation of each variable

Here, the proposed model predicts the laptop prices based on their features. It works by analyzing the dataset of laptop with known price and their corresponding features such as processor speed, memory size, RAM, screen size etc.

TABLE I
Performance Metrics

Algorithms	Strengths	Weakness	Performance metrics
Decision tree	Can handle both numerical and categorical data; easy to understand	Can overfit the data and be sensitive to small changes	RMSE: $107, MAE: $80, MSE: $15,126, R-squared: 0.74
Random forest	Can handle non-linear relationships; robust to outliers	Can be computationally expensive and difficult to interpret	RMSE: $98, MAE: $72, MSE: $12,971, R-squared: 0.79
SVM	Can handle high-dimensional data; effective with small datasets	Requires careful selection of kernel function and parameters	RMSE: $108, MAE: $81, MSE: $16,481, R-squared: 0.77
Regression	Simple and easy to interpret; works well with large datasets	Assumes a linear relationship between variables	RMSE: $80 (best), MAE: $62, MSE: $7398, R-squared: 0.81

From the Table.1, the performance metrics of the Regression model shown properly. The MAE (Mean Absolute Error) value is 62 that indicates the average difference between the predicted and actual price of the laptop. The MSE (Means Squared Error) value is 7398 that means the average square difference between the predicted and actual price of the laptop. The RMSE (Root Mean Squared Error) value is 80 which is the square root of the MSE. At last the R2 is 0.81 that means the model can illustrate 81% of the variance in laptop price with the given dataset.

IV. CONCLUSION

This model can reduce human effort as we don't need to search different sources to get the laptop specifications. Human-centric computing enables us to interact with technological equipment in modern society. It gives economic benefits to the customer for selecting a product in the market. This model is easily understandable for the user in an efficient way. It also gives a good visualization to create a good feasible map of a huge market to investigate and analyze products at different prices. This prediction model is flexible and useful for online as well as offline shopping scenarios. From the above table, we can say that Regression model performs well for laptop price prediction using the given dataset. The 62 MAE value indicates the predicted prices which is closely related to the actual price. Beside the 0.81 - R2 value indicates the variation of the laptop that can predict preciously. It also gives a price-construction-estimation function to retailers and customers. It can fulfil the user to buythe desirable laptop according to purchasing power and budget. So, our model reduces the gap between the estimated and real price of the laptop.

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VI. BIOGRAPHIES

Mehboob Zahedi was born in West Bengal, India. He has pursued his Bachelor of Technology (B.Tech) in Computer Science & Engineerimg from Dr. APJ Abdul Kalam Technical University, Lucknow, UttarPradesh, India. He has pursued Master of Technology (M.Tech) from Aliah University, Department of Computer Science & Engineering, Newtown, Kolkata, West Bengal, India.

He had some experience about the web development during his graduation. He had also done internship in 'Scorpius' for 6 months on the field of web development using Angular, NodeJs, Ionic etc. Then his passion for machine learning began during his postgraduation studies and had continued to grow throughout his academic journey. He had authored 7 (seven) publications like: "Novel Machine Learning Techniques for Diabetes Prediction", "5W+1H Automated Testing in Healthcare: A Case Study", "Innovative Intelligent Systems and Applications: A Swarm Intelligence Perspective" etc. These works demonstrate his ability to apply machine learning techniques to real-world problems.

Md Danish Jamal was born on May 9, 1999, in Adra, West Bengal. He completed his secondary education in 2015 and higher secondary education in 2017 from Kendriya Vidyalaya Ballygunge, Kolkata. In 2023, he graduated with a B.Tech degree in Computer Science and Engineering from Aliah University.

During his academic journey, he undertook an internship at Deductive Cloud Solutions LLP in Bangalore, where he worked as a developer intern. His role primarily involvedworking as a full-stack developer using the MERN stack. Additionally, he gained experience as a React Native frontend developer during his time there.

Dr. Abhishek Das is currently working as an Associate Professor and former Head in the Dept. of Computer Sc. & Engineering at Aliah University, Kolkata. His Research Area is in Medical Image Processing, Machine Learning, Data Science and IoT. He has received a Post Doctoral Research position from University of West Scotland, UK by a Fellowship received from the European Commission. He has also worked as an Assistant Professor in the Dept. of Information Technology, Tripura University (A Central University), India. He has worked previously as a Reader in Computer Sc. & Engineering, Indian Institute of Space Science & Technology(IIST) and Lecturer in Information Technology, Bengal Engineering and Science University, Shibpur(now IIEST Shibpur).

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