# Examining Rental House Data With MRL Analysis:
## An Empirical Approach for Future Perspective of E-Business for Smart Cities and Industry 5.0

Rohit Rastogi, Dayalbagh Educational Institute, India & ABES Engineering College, India*

https://orcid.org/0000-0002-6402-7638

## ABSTRACT

In today's scenario, we all are surrounded with technologies. As the world is shifting towards technology with great pace, and technology is also showing its efficiency and strength, we must appreciate its power. Now the world is shifting towards digitalization. So, it's also important to think that ideas should lie towards e-business to get full advantage of the system. The housing sector is one of the important fields which must get the support of the technological domains to overcome many challenges. So, there is a requirement to bring a system that can direct the work of renter and customer easier. To bring this idea into the real world, the author's team has come up with the idea of a rental house portal system. This portal is a web application which acts as an e-platform to search flats, apartments, property, etc., with scientific analysis-based data. In this system, the owner provides the details of flats with its features and using ML (machine learning) technology, the price of flat is calculated and the customer can check the availability of flat according to his/her requirement and to provide benefits to both parties. As the details of the flat are available on site, there is no need to explain the features of the house to the owner. Customers also have the benefits of searching for the desired house in less time and at a very reasonable price. Therefore, the rental house system is a very nice step towards the finding of flats online. The present manuscript has new thoughts of prediction of house rent price according to the features provided using statistical techniques and has come as one of the best platforms to search the property at a reasonable price.

## KEYWORDS

Machine Learning, Multi Linear Regression (MLR), Test Dataset, Training Dataset, Variance

## 1. INTRODUCTION

In today's fast growing world, people want to do all their work at a higher rate with a greater amount of precision in it. Today; no one wants to waste their resources i.e. money and time, in just doing those things that can be accurately done by machines. During the time of renting a house, people feel that there is a lot of waste of time and resources for searching the best suitable house where they can live with their family.

*Corresponding Author

Searching for a rental house involves different factors that are present in the mind of the buyer, some of them can be like the location of the house, society behavior and nature, area of the flat, number of rooms and balcony in the flat, size of the rooms etc. In small cities, searching for a perfect house manually gives the feeling of worth investment of time, but in the case of large cities, or in metropolitan cities; it becomes a very tedious task to search for a house. So it requires the need for a broker in the process of renting the property. This leads to an increase in the price of the property which affects the capacity of the buyer and also affects the seller as many a time the seller is not able also to get the perfect expected cost.

This problem can be solved by using some techniques that filter the property according to the need of the renter and also provides a fair cost to the renter.

## 1.1 Problem Statement Identification and Hypothesis

Living in a smart environment, where the internet rates are getting cheaper day-by-day, people feel relaxed by getting their daily needs fulfilled on the internet. This also reduces the dependency on other people to get a particular job done. Examining rental house data and making an e-business platform where users and owners can be benefited at the same time.

Before making a prediction on the house rents there are some factors which are considered by authors' team so that analysis can be demonstrated further. The hypotheses are like followings:

- Rental flat price changes with change in basement area, living area, roof area of the flat and the number of rooms present in it.
- Price may vary with the change in the longitude and latitude of that property.
- It may vary with the area zip code.
- Price might rise with the presence of private parking space in the property.
- It may differ with various views available from different flats.

## 1.2 State of the Art and Motivation of the Study

The present scenario of pandemic has shown a difficult time for the world in different fields and in case of the scenario to get a proper place to live at an affordable price, it requires a great research. In the present system, if a person wants to rent a house, then it is very difficult and uncomfortable process. During the time of renting a house, people feel that there is a lot of waste of time and resources for searching the best suitable house where they can live with their family. So, the current scenario of pandemic and also the advancement of people towards e-platform have provided the authors' team a motive to develop a user friendly web-application.

## 1.3 Aim and Scope of the Study

This study aims to segregate the rental property available in the area based on the needs of the user. For this, the user does not need to contact a person and tell him all his requirements so that, he can get the price range and location of the property. Implementing this study on an e-commerce platform increases the renter's trust on the price as they are not randomly generated. It also helps the user to easily decide the requirements based on the budget of the property which can easily be predicted when the user specifies his requirements.

Further this study can be helpful in the market business as it saves the time and expenses of both renter and the owner of the property. This study helps the user to get the best price for their requirements without any effort of visiting any office or to property location.

## 1.4 A Rental House Portal: Need of Current Time

This Portal is a web application which is implementable irrespective of the location. It is acting as an interface between different users (owner and renter). It gives the facility to the owner to display their

properties with its features like location of the house, society behavior and nature, area of the flat, number of rooms and balcony in the flat, size of the rooms etc. on the website by simply registering and by providing personal information (Li, Y. et al., 2016).

The web application is providing some additional features for owners to edit or delete their rent details according to their needs. Customers need to register with the site for the first time and after that they can search for the property according to their requirements.

## 1.5 Usage of Software for Rental House Analysis

In Rental House Portal, there is a data set based on which prediction is made about the cost of the property. This data is collected for an online source. The portal has an attractive and easy to use UI which grabs the attention of a large number of customers (Neloy, A.A. et al., 2019). This portal has a feature of predicting the cost of property based on different features of the property like location of the house, society behavior and nature, area of the flat, number of rooms and balcony in the flat, size of the rooms etc. This cost prediction is made using a Machine Learning algorithm known as multi linear regression technique as it provides the best accuracy for such kinds of datasets (Kaggle; 2020). Using this algorithm the cost prediction can be made more accurate as the number of dependent variables is increased in this (Al-sit et al., 2020).

According to the study made in Bhalla (2008) housing finance has grown at the rate of 36 percent. The authors have also discussed the problem challenges, performances and the prospects of housing finance that the market is facing these days (Bafna, R. et al., 2018); (Liebelt, V. et al., 2018).

## 1.6 Market Significance and Applications in House Rent Domain

Using such smart rental portals not only saves the time of renter but also helps both the renter and the owner to crack the best deal for a property. The renter needs not to physically visit each and every location to get a perfect view of the property. It also decreases the need of a broker in the process of renting or buying a property since every minute detail is available online on the portal. This brings fairness in the trade and in this way helps the market to grow in a good manner (Yadav, R. et al., 2015); (Mohd. T. et al., 2020).

## 1.7 Indian Scenario of Resident's Approach

Various analysis and surveys made by different authorities reveal that with the increase in population of the country, the number of people buying and living in rental houses in different Indian cities is decreasing. According to analysis of India's housing pattern made by the Economic Survey in 2017-18; it has been found that around 54% of the entire population in 1961 that was living in rented properties have now decreased to only 28% (Sreevastan, A. et al., 2018); (Gnat, S. et al., 2020).

According to data mentioned in the 'Institutionalizing The Rental Housing Market In India- 2019', as per the Census 2011 data over 11.09 million houses remained unoccupied in the urban areas of India, despite a massive housing shortage (Khamis, A.B. et al., 2014); (Lee, S.H. et al., 2021).

According to the Fig. 1, which shows a chart of percentage unoccupied rental houses across different cities of India. A pattern is clearly observed; that is the percentage of unoccupied houses is more in larger cities as compared to the smaller ones. This can be mainly due to the large size of the city, less time to invest for searching a property in a big area or a higher per capita income of individuals.

## 1.8 E-Business Growth Amidst Pandemic Threats

In today's time we are submerged in technology and the world is shifting towards digitalization. E-platform, E-business and other online activities are getting lots of positive response. Now, with the arrival of covid-19, it has become more important to promote E-business. The need of present scenario is to produce E-platform in sufficient area as much it is possible. This pandemic has locked

Figure 1. Graphs showing the percentage of Vacant Rental Houses in different Cities of India (Sreevastan, A. et al., 2018)
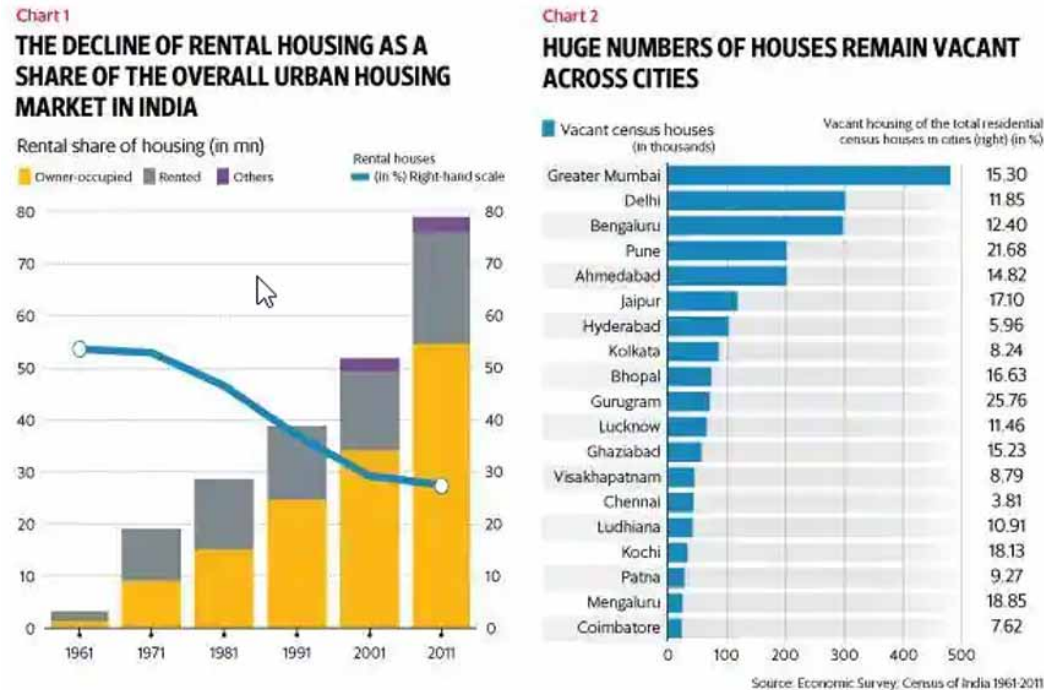


the world inside the houses but the work can't be stopped. So, E-platform is a major choice to maintain the workflow and it has a great future (Ahtesham, M. et al., 2020); (Gnat, S. et al., 2021).

## 1.9 Rental House Software System and its Impact on Market and Commerce

This Portal is a web application which is implementable irrespective of the location. It is acting as an interface between different users (owner and renter). It gives the facility to the owner to display their properties with its features like location of the house, society behavior and nature, area of the flat, number of rooms and balcony in the flat, size of the rooms etc. on the website by simply registering and by providing personal information. Today's society feels easy to perform their task online and the E-platform has also reduces the dependency on other people to get a particular job done (Alfaro-Navarro, J.L. et al., 2020); (Clark, S.D. et al., 2018).

Using such smart rental portals not only saves the time of renter but also helps both the renter and the owner to crack the best deal for a property. The renter needs not to physically visit each and every location to get a perfect view of the property. It also decreases the need of a broker in the process of renting or buying a property since every minute detail is available online on the portal (Croom, B. et al., 2020); (Boeing, G. et al., 2020).

## 2. LITERATURE SURVEY

Vivek Rathi and his team in their research paper, found that there is no rule and regulation to monitor and boost the rental housing sector in India. According to census 2011 data, a massive number of houses are not filled in urban areas despite 11 million houses remaining vacant. In the study, their team has compared different factors which help to grow the rental sector and also focus on government policies. Their research team considered the data set of census of India 2011. According to that, there

are 27 million rental households in India and 21 million rental houses in urban areas. After study, a solution came into light that helps to grow the rental housing marketplace. So, the author team needs rules to manage the market and make rental housing models. In the future, residential stocks will be available. India has potential to grow their market size if India follows the rule and model and it reduces the problem of shortage of rental housing in India (Rathi, V. et al., 2019); (Jiang, L. et al., 2020).

To cover a flawed system, they used e-business models like e-marketing, e-payment for vacant houses and that increase probability to cover unfilled houses. In this study, the authors have considered the broker and if it includes its rental house system, then it affects the price of house unnecessary and it makes price costly. So, their team introduced a machine learning model then it could provide predictions by its feature (Famuyiwa, F. et al., 2014).

Rohan Bafna and his team found there are many middlemen, who fix the overprice of houses and it does not involve the other factor. So, to fix this problem, their team used statistical technology which predicts the residential property price. In their study, the research team have used different methods like hedonic pricing method, fuzzy logic etc. Their author team members gave the solution which is to use the predictor method and remove the middlemen. In future, as per their manuscript, the reliability of house predictor will be increased and it will grow the rental house sector because it is trustable. One may observe in India that there are middlemen who make a deal between buyer and seller. To increase the demand for property, middlemen have to be removed and different methods like multiple linear regression, travel cost methods etc. have to be used (Bafna, R. et al., 2018).

For betterment, if their team involves e-strategy and adds more e-business features like collecting data of consumers from online consumer behavior and from social network etc. then their study predicts more accurate price because it involves new features that focus more in future. In future scope buyers focus on surrounding also and this feature plays an important role in price prediction. Their team takes less dataset and for more accuracy needed large dataset. According to study, they use machine learning modal similar to our study but taking large dataset (Embaye, W.T. et al., 2021).

Azme Bin Khamis and his team established which method is best between multiple linear regression (MLR) or Neural network models to predict the house price. It takes 1047 house samples randomly and retrieves this data from math10 website. So, it includes different features like living area, number of bedrooms, manufacturing date of house etc. To predict the accurate result, they used features of the house and compared which one is better. According to this study, the Neural network model is preferred over Multiple linear regressions (Khamis, A. et al., 2014).

If their team could deploy this comparison on an e-commerce website then it could help more people and it gives a glimpse of which one is more useful and in the future people check that website which uses the best modal and it will help to grow the e-business in the field of rental house sector and makes new opportunities. In their study, they have taken less features for prediction but in reality the model needed more features to predict the price more accurately to the real price (Li, Y. et al., 2017).

## 2.1 99acres

99acres.com is the web and App based property portal. It gives the platform to buyers, sellers and brokers or agents to engage with each other. It gives many features that help the buyer and seller like search the property, advertise, select the property according to their own budgets and also update oneself with news which are related to real estate (www.99acress.com, 2020).

## 2.2 Magicbriks

Magicbriks is a web portal that helps the market to buy, sell and rent the houses and commercial property. It provides different property services like Vastu, home sanitization due to Covid situation and home loans. It also gives the tools and advice to the customer which helps to make good calls about property and the tools are Rate & Trends, Investment hotspot, Research insights and EMI calculator (magicbrick.com, 2020).

## 2.3 Housing

Housing.com is the E-commerce real estate website which helps to search a property based on geography, number of rooms and with other features. They use Data science to predict the neighborhood. According to features, which are provided by analysis, their algorithm also predicts the price of property (housing.com, 2020).

Lirong Hu and his team used social media to collect data instead through census. The census has a challenge to collect data and it takes more time. It takes money and time for data analysis. So, by social media the team members collect data and deploy into the machine learning model and predict the price of house. In this study, they use hedonic model and six different machine model algorithm like random forest, gradient-boosting, support-vector, extra-trees regression, MLP-NN and K-NN. By this study, the modal predict the price by collecting data from particular region by using social media. In conclusion of the study, if we make machine learning model with dynamic data collection from social media then it gives more real time price and it increases e-business because it targets customers from particular regions (Hu, L. et al.,2019); (Babawale, G.K. et al., 2012).

Geoff Boeing in his research found inequality of access to online platforms. Due to backwardness, many people are not able to know the correct information. In this study, resources are used by major communist and those people who are wealthier. So, in this study, more focus on marginalized people, residential mobility, gentrification etc. If information is provided to all people, then they understand rental house price and other information about this to make a good decision. If focus increases on all different types of people, then this sector will see growth and due to the involvement of e-business models, it is easy to sell and buy the house. By using technology, this inequality will reduce and make a new economy with all people beside their caste, community and region (Boeing. G., 2020); (Hu, L. et al., 2019).

## 3. PROPOSED APPROACH

In different research papers reviewed above, there are some gaps like price and it is influenced by third person or by broker. Findings are in a particular area and studies are not focused on new areas i.e, e-business and using small dataset to predict the cost of house. So, to remove this, our study takes a large dataset using machine learning model to remove the broker or middleman which highly influences the price of rental house. Study is not focused on limited areas but it is used more feature to predict the price and it is for online platform so it is accessible to everyone. This grows the people of society who do not want middlemen, due to this; e-business of rental house sector will increase.

### 3.1 FRAMEWORK AND SYSTEM DESIGN

In recent times, finding the houses for rent, is a very hard job and in the tough conditions created by Covid-19, these have made it worse to find a place without any online platform. To overcome this problem, in this project and research work, authors have used ML to provide the price of rent. So, it provides transparency for owner and renter both, and renter has overcome the issue regarding the price and rent.

The proposed Rental House Portal is a web application which is implemented irrespective of the location. It acts as an interface between different users (owner and renter). It gives the facility to the owner to display their properties with its feature on the website by simply registering and by providing personal information. The additional feature provided by the web application for owners is to change their rent details. To search and book the house on this platform, one has to register on the site. The application also uses ML for predicting the price of the house.

## 3.2 ER Diagram for the presented Rental House System

Entity Relationship Diagram shown above describes the relationships of different entity sets saved in the database. It provides a graphical representation of the connection between different entities and also gives the logical database structure by describing the entities, its attributes and providing connection between them (Pl. refer Fig. 2).

In rental house system the different entity sets present are related to each other. Entity sets are shown by the rectangle shape which will act as database table. Attributes are in the oval shape and relationship is shown by diamond shape. Here columns of each table in Rental House System will be the attributes. Owners of the flat have permission to fill the data of the features of house and which

Figure 2. ER diagram of the system
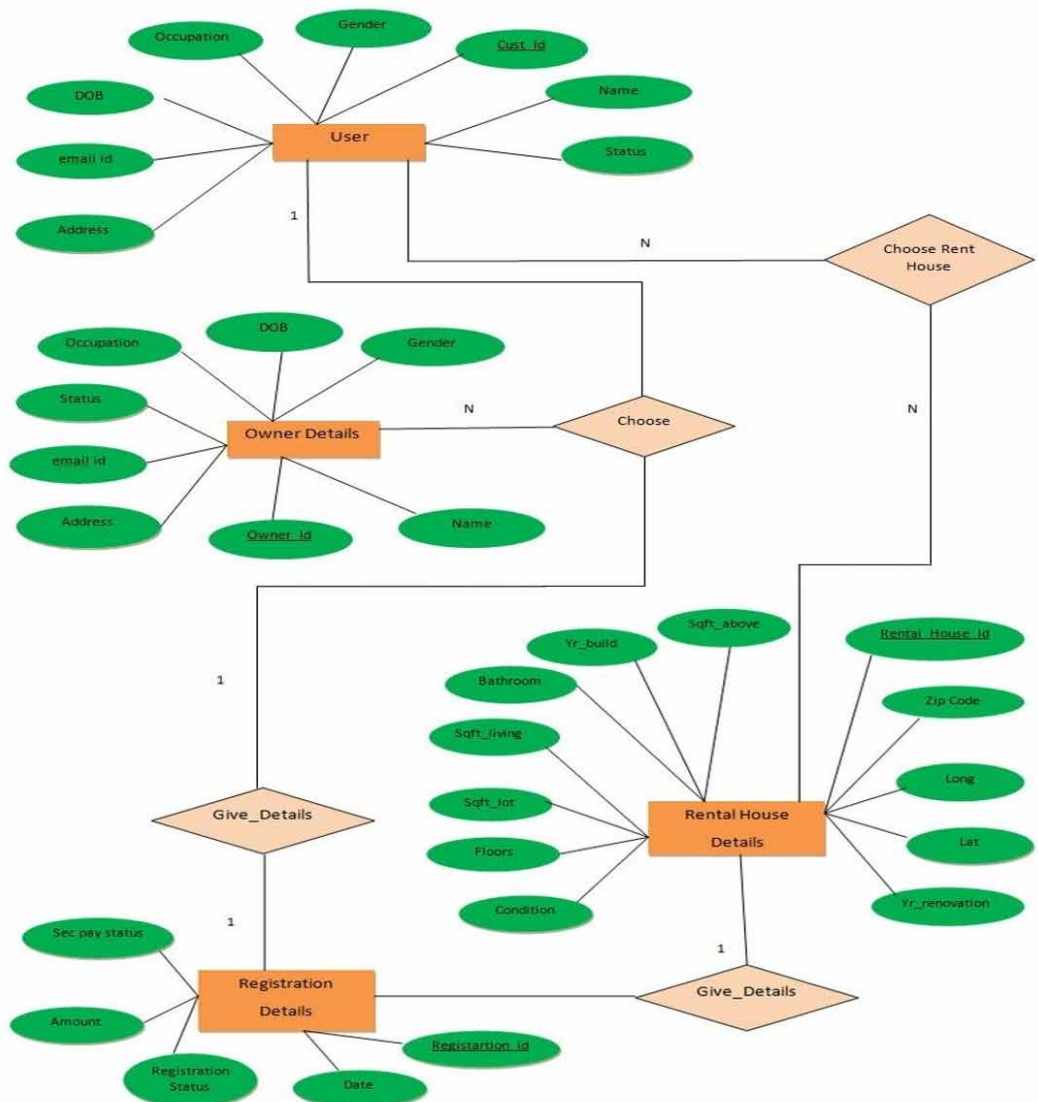
in turn can be seen by the user and can choose the house of their choice. Here the owner and their user have to register to get access to the E-platform.

## 3.3 System Flow Diagram

System Flow Diagram describes how the system is implemented. It is designed in a manner such that the flow diagrams tell about how the system is implemented to reach the desired goal. In the presented flow diagrams, it is shown how the user and owner interact with the system to fulfill their desired needs in a smooth manner (Pl. refer Figure 3 and Figure 4).

In the provided E-platform, System Flow Diagram comprises of different levels. Firstly, the owner has to register and then has to login to enter the required details and home information and all these data gets recorded in the database. After that, the user has to get registered to the platform. To check the availability of flat and to book it, they have to login. The information of house booked by the user is shown to both owner and user.

## 3.4 Front End Design and Flow

For implementing this study and making a practical use of it, the team has used an interface much required. It can be treated as a tool to provide the benefits of this study in the market. In this regard a front end view was made which provides access to the users in 3 different ways- one as an owner, second as a tenant and third as an admin.
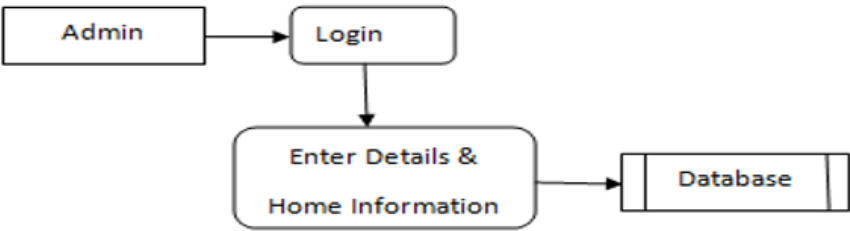
Here, the owner can add his property to the portal for which he can use the price assist feature to get an expected price for his property. It is totally the choice of the owner to either keep the predicted
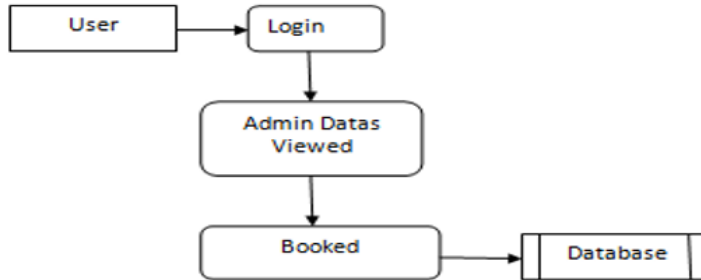
Figure 3. System flow diagram
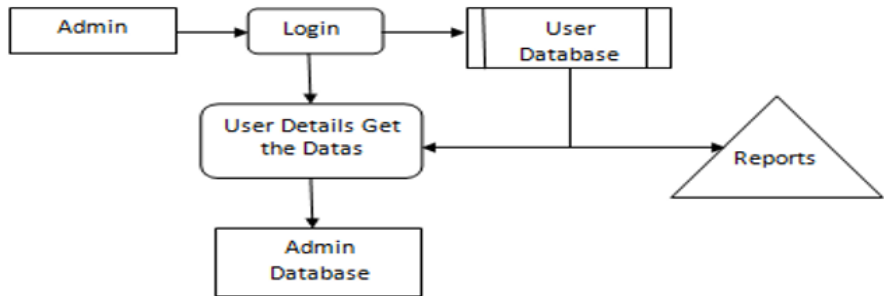
Figure 4. System flow diagram



price or to keep a price of its own. A tenant can make login to see all the property available in an area and can also find a budget for his requirements by predicting one. As an admin, one can keep an eye on all the activities that are going in the portal.

For making a smooth, flawless and attractive experiences for all the users of the interface, the Bootstrap, HTML and CSS are being used, and JS for validation of data entered. A proper navigation has been ensured so that user doesn't get stuck on any page, navbar is available on all the pages,

## 3.5 Back End Functionality

The back end part consists of a database in which all the verified data is being saved for further use. The data entered by users of owners and tenants category are verified by Admin for its authenticity and then allowed for any further transactions. All the information that is fed by the users is kept in the database so that they can be accessed further by the users. For prediction purposes the data entered by the user is being processed by some python code in Flask which returns an integer value (price) to the user.

## 4. EXPERIMENTAL SETUP AND METHODOLOGY

Methodology gives the techniques and methods used to develop the desired systems like the technique for data gathering, different software system design approaches and hardware and software requirements. The team has observed the difficulty of finding the house for rent while moving from

one place to another. So, the concept of developing an online system to overcome the problematic situation was the first step towards the development of the system. Team members have gone through the existing online system and collected the pros and cons for that and these observations have helped them to come up with new ideas to provide a better online rental house system.

The proposed system is a web based system and uses a machine learning algorithm to predict the house rent price. Machine learning has provided a greater impact on the technological boost. By comparing different algorithms, here the authors' team have come up with the algorithm having least error and has been used further in the system to predict the price of rental house.

## 4.1 Sample Data Set and Analysis

Prediction of price of the rent of a house depends on different features of the house, provided in the data set. This data set is taken from kaggle (Kaggle; 2020) which includes approx 25 k columns of the data. To predict the prices of the house, there must be an algorithm which provides the result with better accuracy. Hence, comparing different algorithms like LR, MLR and LRU, the authors' team has achieved a maximum accuracy of 79 percent with MLR algorithm. So, Multi Linear Regression is used to provide the prediction result on the given data set for this system.

In this presented system, there is a data set of features of houses which are marked with their given value and is used to predict the price of house rent. It is done by adopting the machine learning algorithm. The algorithm used here is MLR. The data set used for the purpose of price prediction is taken from kaggle which has approx 25 to 26k rows of data. Here are the rows of the dataset that are included in predicting the price of house rent (Pl. refer Fig. 5).

## 4.2 Column Descriptions and Data Types

- Price: Depicts the price of the flat. (integer, dollar)
- Bathroom: Number of bathroom in the flat. (integer)
- Sqft_living: Total living area. (integer, sqft.)
- Sqft_lot: Total area of flat. (integer)
- Floors: Number of floor of flat. (integer)
- Condition: Condition rating of flat. (integer)
- Sqft_above: Area of roof. (integer)
- Sqft_base: Area of basement. (integer)
- Yr_build: Year of build. (year)
- Yr_renovation: Year of renovation. (year)

**Figure 5. Tabular structure of data set attributes for rent house analysis**

| C price | D bedrooms | E bathroom | F sqft_living | G sqft_lot | H floors | I waterfron | J view | K condition | L grade | M sqft_abov | N sqft_base | O yr_built | P yr_renova | Q zipcode | R lat | S long | T sqft_living | U sqft_lot15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 221900 | 3 | 1 | 1180 | 5650 | 1 | 0 | 0 | 3 | 7 | 1180 | 0 | 1955 | 0 | 98178 | 47.5112 | -122.257 | 1340 | 5650 |
| 538000 | 3 | 2.25 | 2570 | 7242 | 2 | 0 | 0 | 3 | 7 | 2170 | 400 | 1951 | 1991 | 98125 | 47.721 | -122.319 | 1690 | 7639 |
| 180000 | 2 | 1 | 770 | 10000 | 1 | 0 | 0 | 3 | 6 | 770 | 0 | 1933 | 0 | 98028 | 47.7379 | -122.233 | 2720 | 8062 |
| 604000 | 4 | 3 | 1960 | 5000 | 1 | 0 | 0 | 5 | 7 | 1050 | 910 | 1965 | 0 | 98136 | 47.5208 | -122.393 | 1360 | 5000 |
| 510000 | 3 | 2 | 1680 | 8080 | 1 | 0 | 0 | 3 | 8 | 1680 | 0 | 1987 | 0 | 98074 | 47.6168 | -122.045 | 1800 | 7503 |
| 1.23E+06 | 4 | 4.5 | 5420 | 101930 | 1 | 0 | 0 | 3 | 11 | 3890 | 1530 | 2001 | 0 | 98053 | 47.6561 | -122.005 | 4760 | 101930 |
| 257500 | 3 | 2.25 | 1715 | 6819 | 2 | 0 | 0 | 3 | 7 | 1715 | 0 | 1995 | 0 | 98003 | 47.3097 | -122.327 | 2238 | 6819 |
| 291850 | 3 | 1.5 | 1060 | 9711 | 1 | 0 | 0 | 3 | 7 | 1060 | 0 | 1963 | 0 | 98198 | 47.4095 | -122.315 | 1650 | 9711 |
| 229500 | 3 | 1 | 1780 | 7470 | 1 | 0 | 0 | 3 | 7 | 1050 | 730 | 1960 | 0 | 98146 | 47.5123 | -122.337 | 1780 | 8113 |
| 323000 | 3 | 2.5 | 1890 | 6560 | 2 | 0 | 0 | 3 | 7 | 1890 | 0 | 2003 | 0 | 98038 | 47.3684 | -122.031 | 2390 | 7570 |
| 662500 | 3 | 2.5 | 3560 | 9796 | 1 | 0 | 0 | 3 | 8 | 1860 | 1700 | 1965 | 0 | 98007 | 47.6007 | -122.145 | 2210 | 8925 |
| 468000 | 2 | 1 | 1160 | 6000 | 1 | 0 | 0 | 4 | 7 | 860 | 300 | 1942 | 0 | 98115 | 47.69 | -122.292 | 1330 | 6000 |
| 310000 | 3 | 1 | 1430 | 19901 | 1.5 | 0 | 0 | 4 | 7 | 1430 | 0 | 1927 | 0 | 98028 | 47.7558 | -122.229 | 1780 | 12697 |
| 400000 | 3 | 1.75 | 1370 | 9680 | 1 | 0 | 0 | 4 | 7 | 1370 | 0 | 1977 | 0 | 98074 | 47.6127 | -122.045 | 1370 | 10208 |
| 530000 | 5 | 2 | 1810 | 4850 | 1.5 | 0 | 0 | 3 | 7 | 1810 | 0 | 1900 | 0 | 98107 | 47.67 | -122.394 | 1360 | 4850 |
| 650000 | 4 | 3 | 2950 | 5000 | 2 | 0 | 3 | 3 | 9 | 1980 | 970 | 1979 | 0 | 98126 | 47.5714 | -122.375 | 2140 | 4000 |
| 395000 | 3 | 2 | 1890 | 14040 | 2 | 0 | 0 | 3 | 7 | 1890 | 0 | 1994 | 0 | 98019 | 47.7277 | -121.962 | 1890 | 14018 |

- Lat: Latitude location of flat. (integer)
- Long: Longitude location of flat.(integer)
- Zip Code: Zip Code of location where the flat is situated. (integer)

## 4.3 Working of MLR (Multi Linear Regression)

In statistics, Regression is defined as a fundamental operation and includes techniques for analyzing and modeling various variables at a time. Multi Linear Regression is used to describe the relation between a dependent variable denoted by X and a number of independent variables, $X_1$, $X_2$,...., $X_p$. Independent variables are also called as explanatory variables. In simple regression, only one independent variable is present. However, there are more than one variables involved in most real world applications which influences outcome variables. Steps required deploying the MLR model:

- Pre-processing of data
- Fit the Multi Linear Regression model to the provided training-set.
- Prediction of the result of test-set

## 4.4 Formula Used and Explanation

The model of Multiple Linear Regression can be given as:

$$E(Y/X) = \beta_0 + \beta_1 X_1 + \ldots\ldots\ldots + \beta X_p$$

where β0 is intercept and βj are regression coefficients. Error(ε) is defined as the difference between the actual value and the predicted value and can be written as $\varepsilon = \hat{Y} - Y$. Now, equation of regression can be given as:

$$Y_i = \beta_0 + \beta_{01} X_{i,1} + \beta_p X_{i,p} + \varepsilon_i$$

where Yi is the actual value and for the ith observation εi is the error. To measure the ith observation, we write $X_{i,j}$ for the jth predictor variable. Assumptions for the errors $\varepsilon_i$ is $E(\varepsilon_i) = 0$ and $var(\varepsilon_i) = \sigma^2$. $\varepsilon_i$ are distributed randomly. $\hat{Y}$ is used to denote predicted value.

## 4.5 Use of Outliers and Constraints

Outliers are the biggest problem during the prediction process. There are some outliers present in the data set that have behavior opposite to the real trend of relation. It hampers the accuracy of the prediction. So, an important step should be taken to handle the outliers by removing them from the training data set as it shows negative behavior from the real trend. Hence, after removing the outliers we have got the clear view of rental price against the different features present in the data set and it is evident that the prediction has become more accurate.

To understand the condition of the property and location (longitude) which almost does not affect the price of the property, the team has faced certain constraints. After gathering data, during the process of data analysis, it was found that the price of the flats does not change with the change in location (longitude) and the condition of the flat. It is because the data collected to train the model only consist of data of a particular region that is why it does not change with the change in location. And also all the houses were built around the same decade and maintained consistently after a certain period of time and that is the reason the property's condition also seems likely to each other. This may be a possible reason for no deflection in price instead of deflection in the properties like condition and location.

## 4.6 Variables in Analysis for Market Perspective

In Multi Linear Regression, more than one dependent variable is used to model the dependent variable. In Rental House E-platform, the response variable i.e. the price of the house is predicted by using different predictors. Independent variables that are used for the rental house system are Bathroom, Sqft_living, Sqft_lot, Floors, Condition, Sqft_above, Sqft_base, Yr_build, Yr_renovation, Lat, Long. The different predictors are used to have an impact on the price for the rent of house. As the facilities provided increases the price increases and if the quality and number of facilities reduces the price also reduces.

## 4.7 Factors Contributing to Property Value in Terms of Stake Holders

In the present time scenario, for buying and selling of a property one needs to contact an estate agent, many times, the situation occurs that a renter/ buyer/ seller is not aware of the working of the agent, he is contacting. This can sometimes lead to fraud games that an agent can play with sellers and renters. Many times, it is also found that it charges a lot from both the sides and thus resulting in making the property expensive for the renter/buyer and the owner also does not get the desired amount in such cases. Also, many times property is overpriced because of lack of awareness in the owner's mind which results in increasing the cost of property and also becomes a major reason for not getting their flat sold/rented easily.

## 5. RESULTS AND DISCUSSIONS

The above described and presented system is used to predict the cost of the flats and for this prediction; there is a fair need to first understand the data set and to be aware of all the rows and columns that are present in the dataset. For a well description of data it became very important to plot the data on graph and to see the dependencies of different factors on each other. Below are some of the graphs that made it easier to understand the data dependencies.

## 5.1 Implementations

The above graph in Figure 6, shows the fraction of people that prefer buying a house in a preferred range. The graph shows the cost on X-axis as SalePrice and on Y-axis is the fraction of people buying them. This graph shows that the density of people lying in the range 100K to 250K is more than the other one. It also shows the outliers in this data which are those few people that are on the extreme ends.

The graph depicts that for a certain range, the density of population has peaked. The density for which the graph has a high amount of strength lies between 100k and 250k. It signifies that people have the desire to have a rental house with average price and one of the key points of this project is also to provide the rental flat at a reasonable price.

Above figure i.e. Figure 7, shows the choice of people according to the living area of the flat and the cost which they pay for it. Such types of comparison help in getting the people's minds easily. If such graphs are drawn for specific areas then they may also predict the preferences of a particular class of buyers. This graph also predicts the importance of involvement of this feature in the process of cost prediction of the property.

Above graph moves parallel to the thought of a person. As one might think that if the living area is larger, then the rental price is also more and it is true. The graph has clearly shown that the rental price is proportional to that of the living area. One or two points on the graph showing "cheap house" having large areas comes under the category of outliers.

Figure 8 shown above depicts the plot between the basement area of the flat on X axis and the flat cost in the Y axis. This helps in describing the price according to the basement area of the flat and also predicts the choice of the people of the flat based on the basement area. Such graphs help in

**Figure 6. Most of the density lies between 100k and 250k, but there appears to be a lot of outliers on the pricier side**
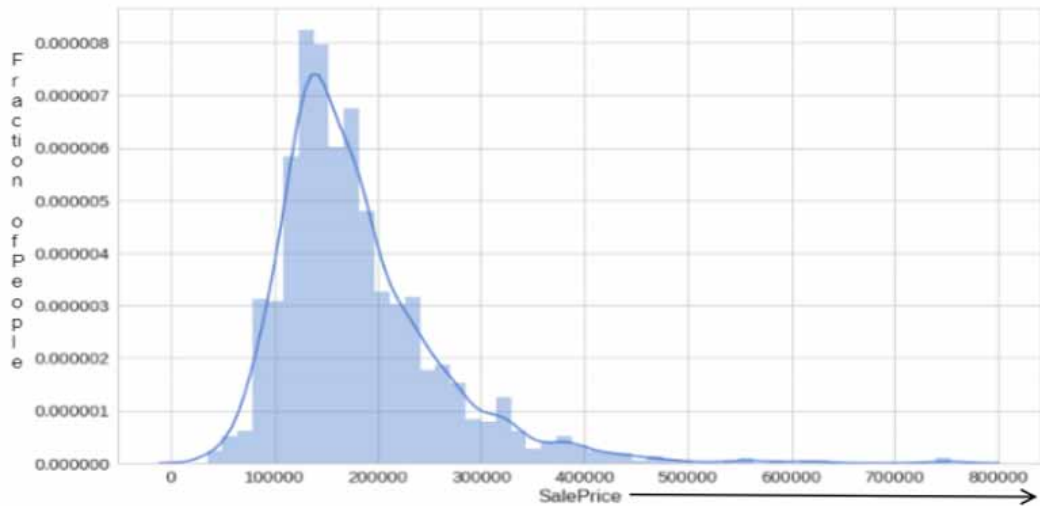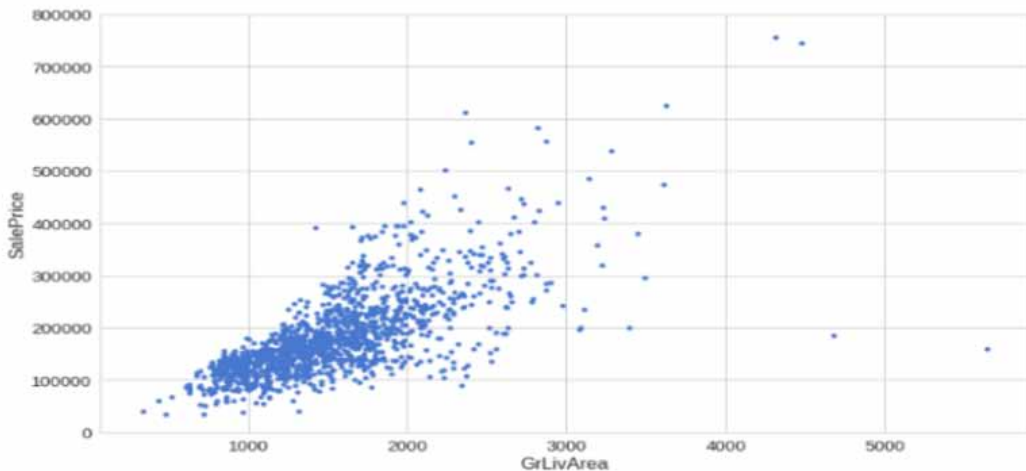


**Figure 7. Sales price vs. total square feet of the living area**



finding out the dependencies of all the factors on which price and selection of a property is depending on. Using such variables in cost prediction will reduce the error and improve the accuracy.

Similar to that of graph shown in figure 6, above graph also shows the proportional behavior. From this graph we have visualized that the rental price increases with increment in total square feet basement area. The more the area of basement is provided in the flat the more the renter has to pay. Some of the flats with larger basement areas are cheaper and are considered as outliers.

The figure presented above Figure 9, shows the relation between Sales price and the Overall material and finishing. It depicts that the houses with good quality of material and finishing are more expensive and it also shows that there is no outlier in the graph i.e. no available building in the plot have good quality of Overall material and finishing and are cheaper.

**Figure 8. Sales price vs. total square feet of the basement area**
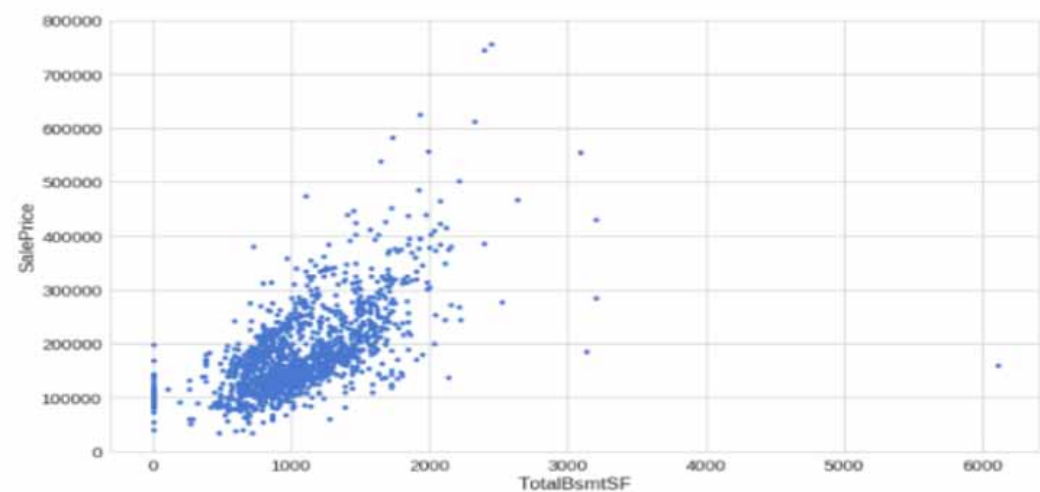


**Figure 9. Sales price vs. overall material and finishing**
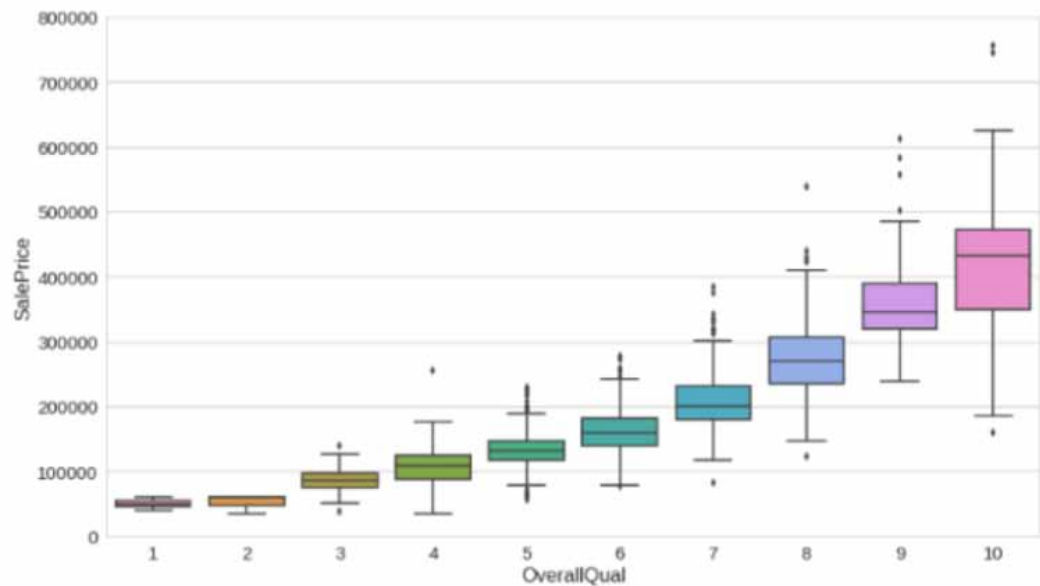


As it has been seen in other graphs that there exist outliers that has a behavior opposite to the real trend of the relation between the values provided on X-axis and Y-axis. The graph marked as figure 8 is free from outliers and provides a clear view that as the quality of the materials provided and the number of features increases the rental price also increases. Different features like year of renovation, number of floors, number of bathrooms, condition rating of flat, etc. are taken into account. This provides a clear view of the rental price against the quality of materials, different features and the finishing provided.

According to this plot in Figure 10, which depicts the Correlation between Sales price and Overall Material parameter of House? It is found that there is a positive correlation with bedroom, bathroom, Sqft_living, view, grade, sqft_above, sqft_basement, sqft_living 15 that are bedroom area, number of bedrooms, square foot area, view, grade of flat, area of roof, basement area, living square foot area respectively.

In the above graph a correlation matrix is prepared among all the columns of the dataset table. The correlation matrix is designed on the scale which shows that red color as negatively correlated pair and blue color as highly correlated pair. From the above graph it can be clearly stated that despite many factors being positively correlated there are a lot of other factors like condition, yr_renovated, lat, long etc whose value are not affected by the majority of other factors in the table. While some of the factors like zip code are negatively correlated on the majority of the factors.

Outliers are the biggest problem during the prediction process. Outliers are the biggest drawback during the prediction process. This is shown in Figure 11, the change in the slope of the graph between price of the flat and the bedroom sq. ft. area. Removing the outliers increases the accuracy of the prediction.

The above graph shows a comparison of a simple linear regression fit of the dataset which includes one with outliers and the other one without outliers. On removing the outliers there were around 872 outliers in the data set. So after removing them from the training data it is evident from

Figure 10. Correlation between sales price and overall material parameter of houses
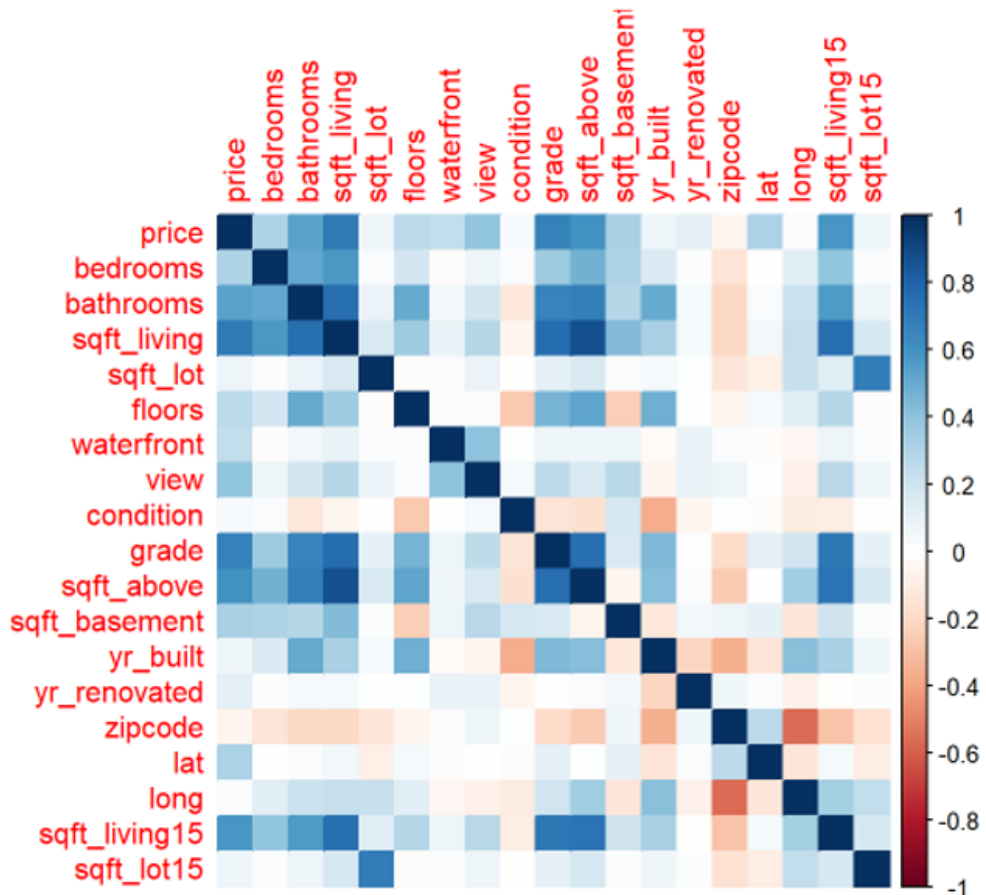
**Figure 11. Removing the outliers reduces the error of prediction of the price**
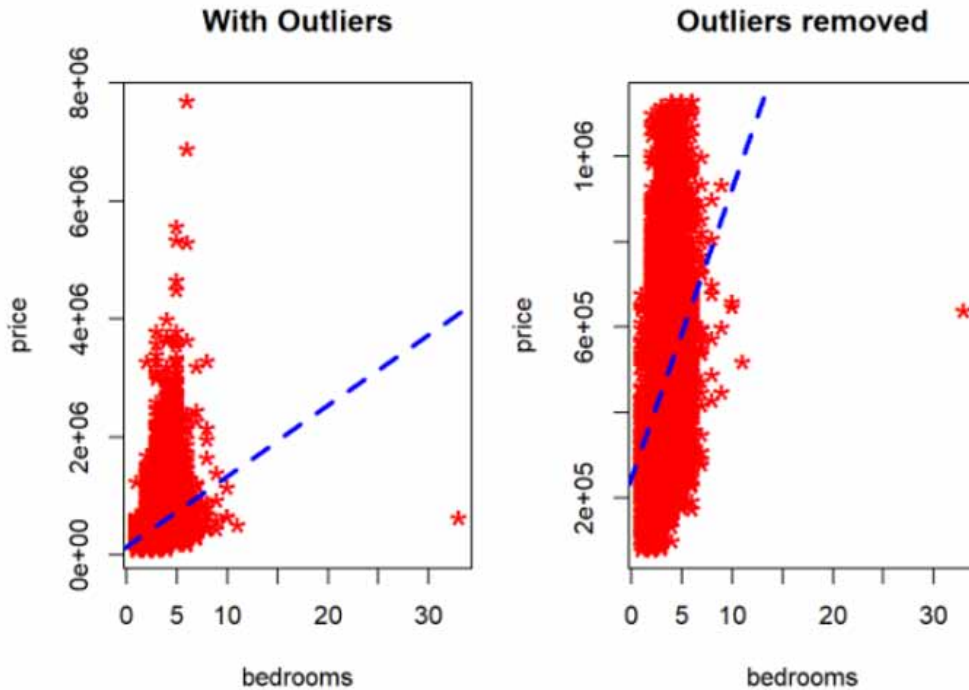


both the graphs that the prediction would be more accurate for higher value of price because of the higher slope achieved after the removal of outliers.

## 5.2 Discussions on Results

After compiling the data and extracting all the important results out of it, it can be observed clearly that this prediction can be used in the market in current times. Adapting to these results not only promote a new era of e-business in the field of estate business but also help the people of different economic slabs of owning their dream house in a minimum possible budget. Opting this provides a better comparison mapping between different properties available in the area and helps people to make the best possible balance between their requirements and financial capabilities. By sitting at any comfortable location a user can make easy comparisons between properties by predicting its costs by varying the features according to his requirements. Its implementation in the current situation of COVID-19 pandemic also helps both the renter and the owner to deal in a contact free manner; neither of them needs to attend any physical meetings to get the best possible deal (Pl. refer Table 1 and Table 2).

Above Table i.e. Table1, shows the choice of people according to the living area of the flat and the cost which they pay for it. Such types of comparison help in getting the people's minds easily. If such data are drawn for specific areas then they may also predict the preferences of a particular

**Table 1. Tabular summary for algorithms and their accuracy**

| Total Square Feet Area | 1000 | 1500 | 2000 | 2500 | 3000 | 3500 | 4000 |
|---|---|---|---|---|---|---|---|
| Sales Price in INR | 10Lakhs | 20Lakhs | 30Lakhs | 40Lakhs | 45Lakhs | 48Lakhs | 50Lakhs |

**Table 2. Comparative analysis of presented work with similar existing works**

| Work Done by Authors | Technology Used | Results of Work and Advantage and Limitations |
|---|---|---|
| Rathi, V. (2019) | Statistical Methods | The authors have considered the broker and if it includes its rental house system, then it affects the price of house unnecessary and it makes price costly. |
| Rohan Bafna (2018) | Hedonic pricing method, Fuzzy logic etc., MLR and Travel Cost Method | statistical technology which predicts the residential property price. the reliability of house predictor will be increased and it will grow the rental house sector because it is trustable |
| Azme Bin Khamis, (2014) | It takes 1047 house samples randomly and retrieves this data from math10 website. | To predict the accurate result, they used features of the house and compared which one is better. According to this study, the Neural network model is preferred over Multiple linear regressions |
| Our Presented Approach | MLR and Statistical tools | The research team has used machine learning to predict the price without any influence of the broker or owner. The presence of brokers has been removed in the process, so the application makes cheaper property for renters. |

class of buyers. This data also predicts the importance of involvement of this feature in the process of cost prediction of the property.

Above graph moves parallel to the thought of a person. As one might think that if the living area is larger, then the rental price is also more and it is true. The graph has clearly shown that the rental price is proportional to that of the living area. One or two points on the graph showing "cheap house" having large areas comes under the category of outliers. (as per Table 1).

*5.2.1 Snap Shots*

Figures 12 and 13 show the front end code of the index page and main booking page respectively where the user has the facility to login through his valid credentials, the user can view different properties, can sort property according to his needs and get the physical location of the property. The front end part is made by keeping in mind the ease of all the operations performed on it.

In above Figure 14 shows a brief description of code showing the accuracy of multiple linear regression technique when it is applied on this dataset. It gives a good accuracy and that is around 79%. This accuracy is checked using the test data set.

**Figure 12. Frontend index code screenshot**

Figure 13. Frontend property page code screenshot



Figure 15 shows a glimpse of the user interface through which the user can make proper contact with the owner of the property. Messages through this will be conveyed in the form of mails.

Figure 16 shows the user interface on which user will land first and can check different features of the site.

## 5.3 Research Findings and Implications

By the machine learning model, it gives the relationship between fraction of people and cost of house where it shows people are interested in buying a house of particular range. It gives the important finding where it predicts the price of property so the important feature of prediction is total square feet of living area. It shows the nature of people and their choice according to living area features.

It gives a relationship between basement area and price. According to study, it is directly proportional to price, if basement area is increased then cost of house will increase. It shows people are paying more for larger basement areas and this feature is important and it gives more accurate price and reduces the error.

Now, another finding shows that the behavior of sale price and material and finishing is directly proportional to each other and it gives high price when material and finishing quality is good.

In the study results showed correlation between sale price and other features. It means bedroom, bathroom have positive correlation and zip code is negative correlation. So, above finding support accuracy and by deployed modal it gives more accurate price according to the dataset.

There are some implication in the study where dataset have some irregularity so, it show on the graph as outliers, which affect the prediction capability and if dataset having string data then this type of data are not useful, to solve this problem needed data preprocessing method and it is useful for training model. In theoretical explanation, dependent variable is dependent on multiple independent variables with less error but in practical it showed outlier in graph that affect the prediction so to remove this hurdle, the data which creates outlier need to be removed the data then it gives more accurate price of rental house.

**Figure 14. Python code for finding the accuracy and performing a prediction on the test data set**

```
pred=model12$fitted.values

tally_table=data.frame(actual=train_data2$price, predicted=pred)

mape=mean(abs(tally_table$actual-tally_table$predicted)/tally_table$actual)
accuracy=1-mape
accuracy
```

```
## [1] 0.7946321
```

```
cat("the accuracy is:", accuracy)
```

```
## the accuracy is: 0.7946321
```

```
date_sale1=mdy(test_data$date)
test_data$sale_date_year=as.integer(year(date_sale1))
test_data$age=test_data$sale_date_year-test_data$yr_built

test_data$reno=ifelse(test_data$yr_renovated==0,0,1)
test_data$reno=as.factor(test_data$reno)

test_data_1=test_data[,c(4,5,6,10,9,12,23,24,17,18,19,11,13,20)]

pred_test=predict(newdata=test_data_1,model12)
```

```
tally_table_1=data.frame(actual=test_data$price, predicted=pred_test)

mape_test=mean(abs(tally_table_1$actual-tally_table_1$predicted)/tally_table_1$actual)
accuracy_test=1-mape_test
accuracy_test
```

```
## [1] 0.789063
```

## 6. RECOMMENDATIONS AND NOVELTY

### 6.1 Recommendations

The research team has used machine learning to predict the price without any influence of the broker or owner. The presence of brokers has been removed in the process, so the application makes cheaper property for renters. By demanding a specific feature by renter in house than the model predicts price accordingly, it makes the process fast and easy for renters. Renters can compare the different features of the houses just by sitting at a place, after using a predictor, no one can manipulate the price and inflation is under control (Mijatovik, M. et al., 2020).

**Figure 15. UI contact page**



**Figure 16. User interface**
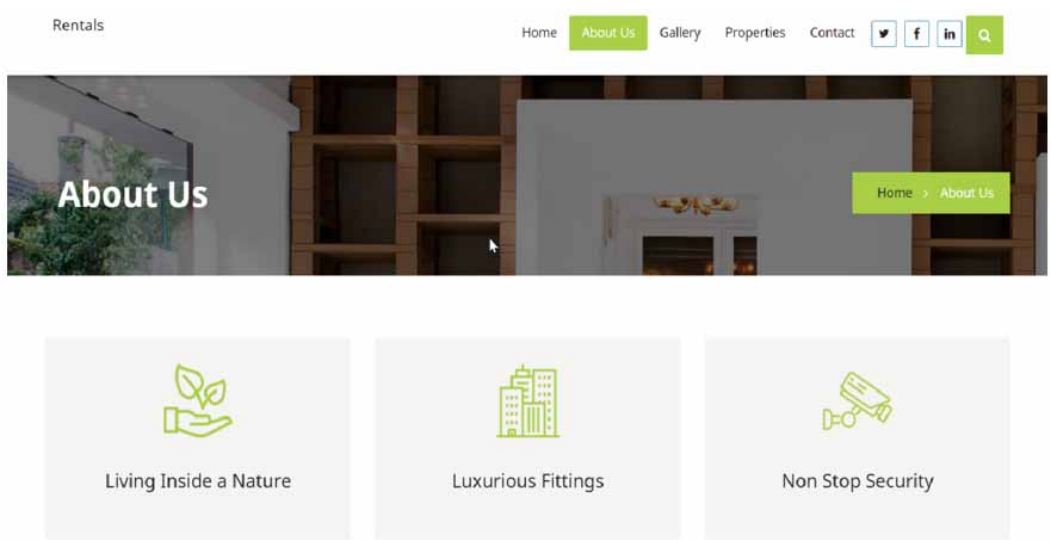


Because it gives fast results and it is available online so by using e-strategy and social media it gives a boost to the e-business of the rental house sector. It gives e-services of renting a house like comparison and it reaches to more people which give the right vision to make decisions.

## 6.2 Novelty

For this study, the team has taken a data sample of approximately 26000 houses. Multiple linear regression was used which is the best regression that predicts the price of a house. Unwanted human factors were removed which increased the value of the house. Due to multiple features, the application could predict more accurate values of houses other than the owner or broker can predict.

In this presented study, the team compared different features to see the sales price and many features like number of bedrooms, waterfront, view, condition, zip code and others were under consideration. So, the study predicted the sales price according to the basement area of the flat and it also focused on material and finishing. It compares sales price with materials and shows price according to that.

In e-business of rental house sector, it is shown the comparison and price according to owner and broker on website so, in this study, it gives price without involvement of broker and prediction of house according to user input features that helps to grow e-business.

## 7. FUTURE RESEARCH DIRECTIONS AND LIMITATIONS

### 7.1 Future Scopes

In future, one may focus on neural network analysis to find error free prediction.

● One may think for adding the feature related to behavior of owner and renter.
● One may decide to develop an alarm system that indicates demand for renters.

In future, the Government will focus on making rental houses model, where that model will have many rules and regulations. These applications will be helpful to increase the scope of rental houses in India. Without professional ventures on it, many properties presently are not sold but development of a perfect product can give the opportunity to the customers and buyers to make a good deal (Hoda, N. et al., 2020).

In future, e-business of this sector have tremendous opportunity when it involve internet of thing, e-market and e-payment which makes easier for user to access e-platform.and do all steps in single window from checking house to payment.

### 7.2 Limitations

● One may take less data set to train our modal.
● One should not use behavioral analysis of neighbors.
● One may do prediction wrong as when less number of datasets is present in any particular area.

In future, one may try to decrease/ vanish scams against customers which are done by few unethical brokers. In the internet world, many brokers are fake and they are applying wrong practices with buyers, sellers and renters. If the database does not connect properly then the data fetching process is failed and no data is available to view the processing. This can also be handled with better programming techniques.

One may give predictions wrong as if data collection is not genuine as it is taken from social media where users give manipulated answers which affect the prediction model. Due to online mode, users may or may not be traceable. It affects the learning of the modal and it gives less accurate price (Dananjoyo, R. et al., 2020).

## 8. CONCLUSION

The purpose of study is to provide the price of a house using a machine learning model and also focuses on the business side. Because technology gives results, but to use this result effectively, one needs to understand electronic business. So, it gives the opportunity to build new e-business theory, a method to boost this sector and make people's lives easier by providing this service through the internet.

In this presented study; the most accurate model is multiple linear regressions among others. MSE stands for Means square error which is less here as compared to other regression. A better data set with different features has been considered here. By using the dataset, this model depicts the people buying houses in the range of particular sales price. The modal predicts the price according to the number of bedroom, view, sqft_living, basement area and it shows the price is proportional to basement area.

In this study for better understanding of the dataset was first important to understand the dataset well. For making a better understanding of the dataset it became very important to first check the behavior of all the factors on which the price factor was dependent. For this understanding we made a correlation matrix of all the attributes of the dataset. It showed that some of the factors are positively correlated to other one while many of them were found negatively correlated on others, it was also showed some very strange observations that there are many factors like condition of the property and location (longitude) which almost does not affect the price of the property. After all this it was the time to remove outliers from the training dataset which were around 872 in number. It increased the slope of the graph which helped in making the best possible prediction of price.

Study shows the good quality of material and finishing are more expensive and it also shows that this model works according to features. To reduce the error, removal of the outlier and it increases the accuracy of the prediction. Study, focuses on the prediction of the prices of houses with less error.

## 9. ACKNOWLEDGEMENTS

## COMPETING INTERESTS

We declare, that we have no significant competing financial, professional, or personal interests that might have influenced the performance or presentation of the work described in this manuscript.

## ETHICAL COMMITTEE AND FUNDING

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*Rohit Rastogi received his B.E. degree in Computer Science and Engineering from C.C.S.Univ. Meerut in 2003, the M.E. degree in Computer Science from NITTTR-Chandigarh (National Institute of Technical Teachers Training and Research-affiliated to MHRD, Govt. of India), Punjab Univ. Chandigarh in 2010. He Received his Doctorate in Physics and Computer Science in 2022 from Dayalbagh Educational Institute, Agra under renowned professor of Electrical Engineering Dr. D.K. Chaturvedi in area of spiritual consciousness. Dr. Santosh Satya of IIT-Delhi and dr. Navneet Arora of IIT-Roorkee have happily consented him to co supervise. He is also working presently with Dr. Piyush Trivedi of DSVV Hardwar, India in center of Scientific spirituality. He is a Associate Professor of CSE Dept. in ABES Engineering. College, Ghaziabad (U.P.-India), affiliated to Dr. A.P. J. Abdul Kalam Technical Univ. Lucknow (earlier Uttar Pradesh Tech. University). Also, He has published more than 100 papers in reputed Inernational Journals and member of Many editorial and Advisory committees. Dr. Rastogi is involved actively with Vichaar Krnati Abhiyaan and strongly believe that transformation starts within self.*