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Impact of Internet of Things (IoT) Data on Demand Forecasting

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Abstract

Objectives: To study the Impact of Data generated from Internet of Things (IoT) on Demand Forecasting. **Methods/ Statistical Analysis**: An exploratory research to study the Impact of IoT data on demand forecasting was conducted. Preliminary information on IoT and Demand Forecasting including the different types of forecasting and data collection methods which was gathered through various available sources. Research papers, journals, Internet sites and books were used to collate the relevant content on the subject. Analysis of almost all the relevant examples was completed as a part of this study. The advantages of Real – Time data i.e. data generated by IoT systems were identified to arrive at the impact on organizations through deductive reasoning. **Findings:** Industrial revolution 4.0 has begun where IoT systems will play a vital role. The population of devices that can transmit data over the network will increase exponentially. Data from such smart devices will get collated, analysed and used in various forecasting models. Since the managerial decision- making is enabled by the forecast, efforts are being put in to align the forecasting model to respond proactively to the market dynamics. **Application:** The IoT data gathered is used in different forecasting models to arrive at the most accurate forecast. Accuracy of the forecast gets verified by the calculated error value and relevancy of the forecasting model is established. This helps the system to be agile and enable corrections on the go in case required.

Keywords: Demand, Forecasting, Impact of Internet of Things, Supply Chain

1. Introduction

Organizations are making substantial efforts to understand customer needs, perspectives and subsequently align them to the organizational objectives and goals for achieving the competitive edge over their competitors[1]. Thus, it makes it vital for the organizations to make their goods and services available at the most appropriate place, time and price[2]. Supply Chain plays a fundamental role in achieving this organizational goal. Supply chain, a term used in logistics, deals with the entire movement of raw material from the first supplier through the chain of suppliers and finally ends with the finished product reaching the consumer. Supply chain fundamentally links the suppliers, organizations and customers/consumers where the activities performed could be within or outside the organizations. Supply chain enables value in the complete chain making products available and providing services to the end customer/consumer[3]. The end customer/consumer raises the demand for the goods for the supply enablement. Demand is the desire expressed by the consumer for the want of a product backed up by a willingness to pay for

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the product[4]. It is imperative that the supply chain begins with demand, and the supplies against the same are dependent on the turnaround time at each step. Therefore, it becomes crucial that the demand transmits through the supply chain as soon as possible. Today the fastest medium available to transfer information is Internet, which is a worldwide system of network. There were nearly 3.5 billion internet users worldwide in 2016 which means about 45 percent of the global population was able to access the internet in the same year. The global average internet speed stood at 6.1 Mbps that year[5]. These favourable figures have given a substantial boost to the number of devices connected over Internet. These devices commonly called Sensors play a role of recording the data at the point of installation. This paradigm shift in the way the sensors connected over the internet gave rise to the concept of IoT[6]. IoT fundamentally includes a world- wide network on which the devices called sensors inter-connect with each other having unique identifiers and their task is to collect data. This data transmitted over internet gets stored in a database. Different business models help resolve different business issues. Demand forecasting, inventory management being a couple of examples. Demand forecasting is fundamentally prediction of demand based upon the past consumption patterns and present trends[7]. This article attempts to study the impact of the different types of data collected from the sensors over internet (IoT data) on the customer demand forecasting with quantitative methods.

2. Demand Forecasting

Forecasting fundamentally is predicting the occurrence of any activity before it actually takes place[8].Forecasts govern the Managerial Decision Making, which then becomes operational in future[9]. Continuous Forecasts get carried out and with time, the accuracy of forecast is measured and calibrated. The forecasts stand corrected if required and at times decisions fine-tuned/altered to suit the business requirements.

The forecasting methods fundamentally get classified into two types, first being the qualitative/ judgemental type and second one is quantitative type[10]. The vital choice of the forecasting type to use made by the manager in an organization depends on the accuracy of the forecast. Qualitative methods of forecasting include the collective intelligence and experience of individuals who all are together predicting the outcome of an event[11]. This method is generally in practice when there is not enough data to predict or the variable data cannot directly get in a numeric model. Quantitative type of forecasting either use statistical analysis of the past data to predict the future i.e. called Time Series method or use statistical analysis to figure out the causal relationship between the independent and the dependent variable i.e. called Trend Projection Method[12].

2.1 Time Series Method of Forecasting

Time Series is a collection of data gathered sequentially over a particular time- period[13]. The goal of the time series method of forecasting is to predict the future values of the series depending upon the past values. "Trend" is the variation observed in the data series over a period. The causes that affect the variables are unknown in a time series. However, we examine the past behaviour of the data to predict the future behaviour[14]. Time Series analysis comprises of two steps.

1. Building a model that represents the time series
2. Using the model to predict the future[15]

Examples of time series data include dispatch data collected on an hourly basis, Sales data gathered on a daily basis or Temperature of an area measured daily at One' o Clock. The representation of the Depiction of Time series forecasting is as shown in the Figure 1[16].

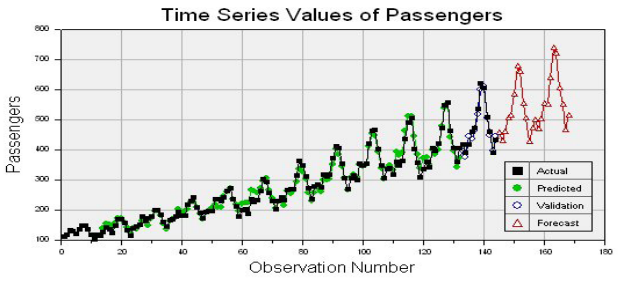

Figure 1. Time series value of Passenger.

Conventionally there are two types of data gathered in a Time Series, Continuous and Discrete. Continuous data consists of observations gathered on a trace seamlessly such as an ECG wave while, discrete data includes

observations those taken at set periodic intervals such as temperature measured on hourly basis[17]. Different type of methods, such as simple mean, weighted average or weighted moving average are available to arrive at the next forecasted values basis the captured data[15].

2.2 Causal Method of Forecasting:

Causal Method refers to study of a data, which relates to another variable that is of interest, and use of the same for forecasting[18].Building a statistical model, which represents the best relationship between the dependent and independent is the fundamental objective of causal forecasting method[30]. It's used to establish the cause and effect relationship between the dependent variable and the independent variable or variables. There are two pre-requisites to use the Causal Method of Forecasting.

a) The dependent and independent variables need to have a relationship between them.
b) The values of the independent variables cannot be known[18].

This method uses the Liner Regression Technique where the most tedious and rigorous one being multivariable regression analysis[18].Data gathered is plotted on a graph as a scatter plot with the dependent variable on the Y- axis and time on the X- axis[19]. As per the methodology, a straight line gets drawn through all the data points such that the line comes closer to all the data points[19]. This results in a straight-line equation i.e. y = mx + c or the model, where x represents the value of time on the x- axis and y is the forecasted parameter. The values of "m" i.e. Slope and "c" i.e. Constant are calculated and replaced in the equation/model[19]. Thus for different values of variable "x", it is possible for us to predict the resultant "y"[19]. In a causal method when only one single dependent variable is involved, it is simple regression equation. However, in multiple regression models the regression equation has more than one dependent variable is present[19].

Examples of Causal methods include impact on sale of automobile spare parts by noting the vehicle sale patterns, or change in the sale of medicines due to change in the climatic conditions etc.

Figure 2indicates the Linear Trend model where the value of variable "Y" is predicted for the different values of time series variable "t" with the model equation Y = 10.2889 + 0.25861 t[20].

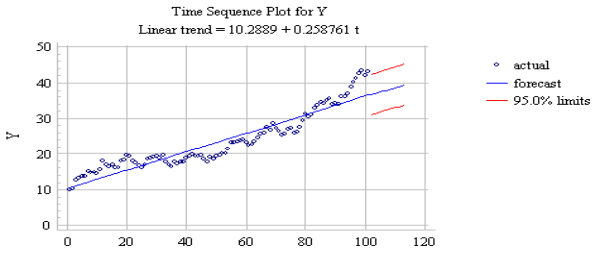

Figure 2. Predicted value of Y against different values of time variable – "t".

3. Data collection and its Automation with IoT

There are two types of data used in Forecasting:

a) Primary Data
b) Secondary Data.

Primary data refers to the data that which is collected for the first time from the respondents or devices and does not have any prior existence. Secondary data is a previously collected data and has applicability in the current scenario[21]. Data collection is often very expensive. On the other hand, reliable data is required to verify a quantitative model. The data gathering could include observing and recording of complex and multidirectional data. Manual recording of data, most of the time, suffers with bias and recording errors, hence automatic data collection gained more importance and acceptability[22].

There are sensors (physical objects) placed at the data collection points with unique identifiers that work in a collaborative, interconnected manner and transmit the data over internet to a central repository for enabling meaningful analytics. This defines Internet of Things used for data collection. IoT fundamentally is the next generation of communication over the internet consisting of trillions of nodes, which represent the smart devices, i.e. sensors, large web servers and supremely powerful computation clusters[23]. IoT becomes more and more interesting when we observe that a combination of electrical and mechanical parts start behaving intelligently along with the hardware, software, sensors, data storage and connected over a global network. In last five decades, we have seen Internet grow substantially initiated by micro network and grow to a macro global network. Billions of things got connected because of this evolution in the past few years globally[24]. The rapid

development that IoT systems have undergone make the smart devices interact effectively with each other in the eco-system and generate real time data, which can be fed in any application[25]. Enormous potential is unleashed due to the advancement in the IoT technologies where common physical objects can be connected, monitored and managed by a single system[26]. The data generated by the IoT systems is with a rapid pace and hence the requirement of a high throughput processing arises, which could be challenges going forward with the IoT Systems.

4. Benefits of Using IoT Data in Demand Forecasting

Data plays a crucial role in the quantitative method of forecasting. If we consider Time Series forecasting, the data captured over the past helps arrive at the future trends. Whereas in case of causal method of forecasting, the data is gathered for the Independent variable to determine the values of the dependent variable using the forecasting model. The type of data used in both the above methods would be mostly primary data. Primary data should be collected in an unbiased manner and with minimum error. We can achieve the following benefits in using real time data to be used in analytical models for forecasting demand.

4.1 Agility

Real time data enables managers do course corrections in decision making depending on the forecasting output preventing further losses to the organization. Real-time insights into the forecasting errors facilitate organizations react rapidly to mitigate the effects of an operational problem[27].

4.2 Strategic Advantage

Markets are dynamic in nature. The only way to remain one-step ahead of the competition is to get notified instantly about the changes in the market scenarios and changing the strategy to align[28].

4.3 Revenue Growth

Service improves drastically when the customer demand is monitored and proactively responded. Failures predicted and attended in time improve the revenue of organization considerably. Better insights coming at real time also lead to better revenues[29].

4.4 Cost Savings

With real time data, there is no waiting time for the managers, which also results in freeing of the resources previously deployed for data collection and responding to the customers[28].

4.5 Accuracy and Relevancy

The accuracy of the forecast model increases due to the continuous fine– tuning that happens with the use of real time data for predicting the future. This also takes care of the relevancy facet of the forecast with the current trend making it more effective for decision making[28].

When the forecasting models are developed, the decisions on the alternative model is taken based upon the recent vintage of historical data available. The alternate forecasts are analysed by generating the outputs and comparing the resultant forecast errors. The comparison is also extended to the forecast generated based upon the real time data. This gives two types of advantages[30]:

1. Model can be built on a richer data and
2. The data revision can happen over time

5. Conclusion

Customer needs and perceptions are changing at rapid pace. For organizations to survive, aligning to these changes with agility will be of paramount importance. Accurate forecasts will play a vital role to support the managers for correct decision making. The study of the current research literature reveals that the accuracy of forecast increases with the usage of real time data collected automatically by the deployed IoT systems. With 3.5 billion users using internet in a single year at an average speed of 6.1Mbps[5], it becomes one of the most significant media of data exchange on real time basis. Precise forecasts facilitate businesses gain and sustain their strategic position in the market. Organizations get assistance with the facts to do the necessary changes in the strategies for mitigating the market risks. Research literature further reveals a growth in revenue and reduction in costs for the organizations who have adopted IoT data[24] i.e. real time data for demand forecasting. Improved serviceability because of accurate forecasts can help the businesses in achieving higher customer satisfaction.

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