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Intelligent Transportation Systems Using Big Data Analytics

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Abstract--*Intelligent Transportation Systems are set to innovate and revolutionize the way current transportation systems work by creating safer and more efficient transportation methods. ITS generates large, rapidly increasing volumes of real time data from various sources which proves difficult to process and store. Real time data is very important for various traffic related applications and to solve various problems in day to day traffic scenarios. Innovative big data techniques are emerging rapidly in the field of ITS and are solving the problems which conventional systems cannot. In this paper, first we will touch upon the characteristic features of Big Data and Big Data analytics. Then the various Big Data platforms are discussed along with the data collection methods employed by Big Data Analytics. Finally, the various Big Data techniques which are popularly used for various ITS implementations are discussed.*

Key words--*applications, big data analytics, features of big data, machine learning algorithms, survey*

I. INTRODUCTION

Transportation systems are quickly evolving and developing due to the increasing demand for automobiles. The world is quickly turning its focus towards ITS which is being called the future of transportation. ITS are being widely developed and deployed to attain traffic efficiency. The present modern day cities face various traffic related problems daily such as traffic congestion, slow traffic, badly planned routes, less than efficient regulation of traffic and more which serves as a massive inconvenience while going about our day to day lives. It delays us immensely as we spend a large part of our daily lives stuck in traffic, or navigating through stubborn, slow moving traffic. With a wide application of ITS to these scenarios, these problems can be reduced greatly. ITS can inform commuters with prior accurate information about traffic, information about the real time traffic in various parts of the city, and more. The technology of ITS is being adapted and used in various parts of the world. It is not only used for traffic congestion problems, but another major focus of ITS is to increase the road safety for drivers and passengers.

For example, the city of Glasgow uses ITS to give regular information to the citizens about availability of seats, bus timings, time the bus takes to reach a particular destination on that day, etc. All the buses are equipped with sensors to facilitate the periodic updates that the commuters receive regarding the buses.

Another very important use of ITS is the periodic surveillance of roads. Surveillance is typically done using CCTV cameras which are set up along most of the busy and important roads in every city. Road surveillance is very important for the safety of a city.

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In the case of natural disasters, the evacuation of citizens and escape route planning of the city can be done using ITS. Many proposed systems of ITS deal with real time data and the collection and processing if real time data will provide valuable information about the current state of traffic around various parts of the city.

Since this data is already stored, in the case of an emergency it can be put to use in order to determine the shortest and least congested routes for escape and evacuation in a much more convenient way that current systems. In this way ITS aids in the integration of the safety of citizens.

In this world which is rapidly urbanising, a large portion of the population is swiftly leaving behind rural areas and seeking the lifestyle and employment benefits of the urban areas. This in turn increases the number of automobiles that commute daily in big cities. Traffic congestion increases as the population goes up. Unfortunately, most of the cities are badly equipped and do not possess the infrastructure that is required for rapid urbanisation. ITS can be used to plan and create systems to decrease the traffic congestion and accommodate the needs of growing cities. One method by which ITS can do this is by creating a model by which multi modes of transportation are equally involved like walking, buses, trains, cars, etc. By implementing this traffic congestion can decrease tenfold.

ITS uses various types of technologies to develop a wide range of applications which can be used to integrate simple traffic scenarios. Some of these applications are CCTV systems, systems to manage traffic, toll booths, vehicle registration systems, automatic vehicle detection systems, and many more.

In ITS, data is procured from a wide range of sources such as traffic cameras, smart sensors, smart cards, social media, dash cams, etc., ITS aims to collect data faster, process data more optimally and store data efficiently. By doing all of these, the scenario of traffic management will change and traffic congestions and inconveniences will reduce. Planning of traffic and traffic routes will become easier.

II. EXISTING SYSTEM

The existing system of ITS consists of the following layers:

The data collection layer – the layer where the collection of data is conducted. The data in this layer comes from various sources such as social media, sensors, CCTV cameras, vehicle dash cams, etc.

The data analytics layer – the layer where the collected data is cleaned, stored, analyzed and shared.

The application layer – the layer where the processed data is put to use for a variety of applications such as traffic flow prediction, traffic anomaly detection, transportation planning, etc.

ITS face a lot of challenges, but one of the main challenges is the amount of data that is produced by ITS. ITS produces rapidly increasing, large, fast data which is very difficult to handle, process, and store.

Due to the massive amount of data that is produced, the processing of data proves to be a major challenge and it creates a chain reaction of less optimal functions as real time data cannot be computed rapidly. Real time data is necessary for various implementations such as emergency systems, traffic route planning systems, etc.

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III. BIG DATA

Big Data Analytics is the vast and complex process of analyzing large sets of data in order to obtain various types of useful information from it. This information can be of various formats such as different hidden patterns, new and upcoming trends and various relations between the data. This knowledge that is obtained using big data analytics can be put to use in a variety of ways. It can be used in various fields which produce large data sets. Using big data analytics, ITS can improve the efficiency of transportation in many ways.

Big Data is a widely popular field which is still emerging in a lot of practical applications but the scope of using Big Data Analytics in every field is massive, The many advancements made by implementing Big Data Analytics has been widespread and very effective.

Along with the growing population and increasing urbanization, the amount of data that needs to be processed and stored in various fields is massive. These fields include healthcare, education, and even transportation. By harnessing the many advancements that big data analytics has provided, mankind can make many innovative leaps forward across a broad spectrum. The characteristics of Big Data are:

Volume

Big data analytics can classify, process and store extremely large volumes of data. The method to analyze the data is determined by the volume of the data.

Variety

Data which is obtained is of various types and formats such as audio files, video files, text, images, etc. The data is effectively put to use by determining the type and format of the data.

Velocity

Since there are such huge volumes of data, the speed of processing and generating the data is very important. Big data analytics aims at improving the efficiency of data processing and storage. Big data analytics also deals largely with real time data and this type of data needs to be processed and stored very rapidly in order to meet the desired efficiency of functionality.

Veracity

The data obtained might have a lot of abnormality. This abnormality needs to be cleaned out of the data before it can be analyzed and stored. Advanced tools need to be used in order to do this.

Fine-grained

The information obtained needs to be then properly stored and recorded.

Relational

Once the data is analyzed we check to see whether the data obtained is similar to or has common fields with another data. If so then it can be joined together.

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Extensional

We should be able to add new fields and subsequently modify the fields added without having to greatly alter or modify the data.

Scalability

The size of the data stored should expand according to the storage needs of the data obtained.

Value

The value of data can be determined by the amount of information that can be inferred from it.

Variability

As new data is being generated, the value of the data needs to change periodically in accordance with the newly generated data.

Big data analytics can add the following benefits to further improve ITS:

As we know, ITS generates a large and varied amount of data. In order to put the data to use, it needs to be cleaned, processed and stored. And this needs to be done in optimal time in order to integrate the current system of transportation. Big data analytics can be used to solve this purpose. There are various platforms available in big data analytics which can meet the specific requirements of various types of data.

Big Data analytics could improve the operation efficiency of ITS. Many systems in ITS need to handle huge amounts of data to provide information or to provide decisions to manage traffic. big data analytics can facilitate rapid collection and analysis of real time data which can in turn be put to use in various scenarios such as in the case of an emergency or an evacuation. Big Data can also help the public transportation system to analyze and learn the patterns of the regular commuters which can be put to use for the better regulation and planning of traffic. This can also help to aid commuters and give them information about reaching their destination in the most optimal time.

Big Data analytics can also improve the safety level of transport. Using advanced sensors, we can detect a chance in the occurring of traffic accidents. This done by collecting historical traffic patterns and analyzing it. In case an accident takes place, it requires a lot of immediate response from various elements such as healthcare, traffic, etc. Big data analytics analyses real time data efficiently which can help us greatly much more quickly in this time. In this case of any repair issues in automobiles, big data analytics can be used to make maintenance related decisions ahead of time. This will reduce the occurring of repair issues.

Data is collected in various ways using Big Data Analytics:

A. Big Data from GPS

GPS is the most popularly used element for tracking the location of an automobile. Traffic data can be collected more efficiently using GPS and the security risks are minimized. By using geographic information system (GIS), GPS provides a well-organized tool for data collection. Using this information we can then go on to implement it in various applications such as detecting the congestion of traffic, finding the shortest route, etc.

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B. Big Data from Videos

Video cameras have a very widespread usage in ITS. Video cameras are a good alternative for sensors and they can aid tasks such as traffic flow detection and vehicle identification. They are advantageous as they are comparatively cheaper than sensors to detect traffic flow

C. Big Data from Sensors

Sensor equipment which are installed in ITS are used for data collection such as the speed of vehicles, vehicle times, vehicle routes, etc. Data that is collected from sensors can be classified into three types of data:

Wide area data is the data that is obtained from a wider area of traffic. The data collection is not limited and spans a wider area limit. This data is collected using sensors that span a wider geographical range. The collection devices include traffic detection devices, traffic video processing, traffic cameras and more.

Modern transportation systems are equipped with a variety of sensors which are located along the roadside for a variety of purposes such as to monitor the flow of vehicles, to detect vehicles, to detect accidents, etc. Examples of roadside sensors are inductive loop sensors, magnetometers, microwave radars, etc. ITS rely heavily on sensors to maintain the safety and organization of traffic flow.

Floating car data is obtained from the cellular networks available in mobile phones present in vehicles at any given point of time. It is used primarily to assess the speed of traffic flow and based on that. Information like the approximate travel time, the rate of congestion of traffic, etc. The advantage of floating car data is that it is not a stationary method and it moves along with the vehicle. Other devices such as cameras and sensors are stationary and cannot provide us with the same type of information. Another advantage is that floating car data reduces the cost of hardware as only one element is required whereas cameras and sensors require a large range of hardware.

D. Big Data from CAV and VANET

Connected and autonomous vehicles (CAV) are recent technologies in ITS which can reduce the risk of traffic accidents and making the efficiency of transport better. Connected and autonomous vehicles involve various technologies that aid in the safe movement of people and vehicles on the roads. They can reduce congestion and travel delay and can also provide safe performance. They generate large amounts of real time traffic data such as the speed of a vehicle, the location of a vehicle in the form of ITS coordinates and more.

Vehicle Ad Hoc Network (VANET) is a type of mobile ad hoc network that employs nodes such as vehicles and the infrastructure elements of the vehicles. VANETS generate a big amount of data. These large volumes of VANET generated data can be analyzed and processed using Big Data Analytics.

E. Big Data from Smart Cards

Most of the big cities use smart cards to aid efficient transportation. For example, public transportation systems such as buses and trains use smart cards. Smart cards can be recharged and swiped before boarding the transport and the fee is automatically deducted from it. The cards also have information such as passenger details, the transport routes they used, the duration of the transport, etc. This is not only convenient but also safe. It can also be used to study the transportation patterns of the public and the routes they take. In the case of any

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emergency this information can be used to track the movements of the smart card holder. It also helps transportation systems to have a general idea of how many people commute per day, the most popular places that citizens commute to and more such informative details. Using these the transportation systems can be modified according to the needs of the travelers.

F. Big Data from Other Sources

There are some data sources which cannot be grouped into the above mentioned categories of data collection. For example smart grid is used to collect the information about the electricity consumption in all the trains and other vehicles that use electricity. Field tests are conducted in train ground areas to analyze the communication between them. A large quantity of data about the trains is obtained from these tests.

G. Platforms

Big Data platforms are a major reason why Big Data is evolving in the field of ITS. There are various platforms in ITS which are capable of handling the large volumes of data. Handling of real time data is another important feature required in ITS as a lot of Big Data applications require the fast processing of real time data. This is necessary in situations such as emergency evacuations during high traffic congestion hours, etc.

Some of the most popular Big Data platforms are:

Apache Hadoop

Distributed processing is a very attractive feature of a platform when it comes to dealing with large datasets. This is because a single point of failure is not a feature of distributed systems and hence it is more fault tolerant and safe. Apache Hadoop provides the distributed processing framework. It also provides distributed storage which is enabled using the MapReduce framework. Hadoop also provides a diverse environment for processing the various formats of data that is produced in ITS.

Apache Spark

Spark operates by dividing data into clusters which it then processes and stores. This functionality of Spark makes it fault tolerant which is an important aspect that is required in processing big data. Spark is effective for Machine Learning approaches.

Apache Sqoop

Once the data is processed it needs to be transferred to a relational database for storage. Sqoop is an effective tool for performing this functionality. It injects the data from Hadoop to the relational database which is then going to store the processed data.

IV. LITERATURE SURVEY

The problem addressed by Karim I. Moharm, Eslam F. Zidane, Mostafa M. El-Mahdy, and Samah El-Tantawy in Big Data in ITS : Concept, Case Studies, Opportunities, and Challenges is that as technology becomes more advanced, more advanced and efficient tools are required to analyse and store this data. ITS faces the same problem. The data that needs to be processed come with various different characteristics and require tools with specific features to process it. Big Data can be called as datasets that have a large volume, large variety and large velocity. This type of data is hard to clean analyse and store. The various types of data

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procured in big data can be classified using various methods. The data can come from social media, be structured or unstructured, it can be either document or graph oriented. It can also sometimes work based on the key value pairs present in the data. The data will be processed according to where it comes from and also the characteristics of the data. For example, it can be batch processed or stream processed. The advantages of using big data in ITS is that it can improve the efficiency of business by predicting new customer trends, it can improve the decision making capabilities by analysing the data. This paper also talks about how cloud computing is used to help computers to perform parallel processing of data. Cloud computing provides elasticity and scalability. Big Data problems can be solved with scale up or scale out systems. Scale up systems employ non parallel architecture whereas scale out systems employ parallel architecture. Hadoop is an example of scaling out architecture. Hadoop is a distributed processing system which employs MapReduce. Hadoop has only a limited performance for real time processing of data.

Liu Yang in Big Data Technology and it's analysis of application in urban ITS talks about how at present, there are varying levels of traffic congestions in different cities. This traffic congestion leads to a lot of problems like severe effects on people's travel experiences and it also increases risk of traffic accidents. This paper proposes a model which will analyze the value and features of big data technology and create an efficient model of the urban ITS system using using GPS, GIS and structure in order to make the problem of traffic congestion better. GPS is Global Positioning System which makes the geolocation of any destination on earth available to the commuter as long as there are no obstructions blocking it.

GIS or Geographical Information System is a platform for collecting, managing and analysing data. It analyses locations and organizes layers of information about the data by visualizing it using maps and 3D scenes. Using these features, we can find more information about the data by deriving the relationships, situations, patterns and these aid he users to make better informed decisions.

Li Zhu, Fei Richard Yu, Yige Wang, Bin Ning, Tao Tang in Big Data Analytics in ITS: A Survey analyse how big data is becoming an emerging trend in the field of ITS. ITS derives data from various sources such as GPS, video cameras, CCTV, social media, etc. This data is of various formats and is very large and dense in volume. The processing of this data deems to be a difficult task as the processing and storage of this data is very difficult. This is where Big Data Analytics comes in and can be used to solve all the problems and perform the tasks that traditional platforms cannot do. There are various big data techniques which are used such as supervised learning, unsupervised learning, deep learning, etc. Big data in ITS mostly uses machine learning techniques. Using these techniques the data can be processed using platforms such as Hadoop and Spark. Hadoop and Spark are both very popular platforms when it comes to ITS. For the storage of this data NoSQL databases such as MongoDB and CassandraDB are used. NoSQL is used as the ITS produces various formats of data and relational databases are not efficient in storing various formats of data. The various applications of big data in urban ITS are mentioned as traffic flow analysis, accident detection, traffic control and management and more.

Tasneem S. J. Darwish and Kamalrulnizam Abu Bakar in Fog Based Intelligent Transportation Big Data Analytics in The Internet of Vehicles Environment: Motivations, Architecture, Challenges, and Critical Issues say that big data was implemented in ITS in order to increase safety and efficiency of transport. But as the demand for transportation is increasing so is the volume of data that needs to be processed and stored. As all

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the various devices which are used to collect traffic data are all distributed over a wide distance and are all in geographically different locations it is difficult to transfer the data from one place to the other. Slow transferring of data creates overall data congestion and in turn leads to slower processing of data. And big data platforms needs to be fault tolerant and centralized and a massive delay in the processing will not be compatible with the platforms. This problem can be solved using fog computing. Fog computing can be integrated into the system of cloud computing and big data and can help us to save the network resources used in the process. Fog computing helps us to distribute the processing of data over the edge of the cloud and due to this the network resources are saved. This paper also proposes a model which combines the IoV environment with the fog computing, cloud computing and the big data analytics environments. The opportunities and challenges which may occur when fog computing and big data analytics are merged with the IoV environments.

Fan-Hsun Tseng ,Jen-Hao Hsueh, Chia-Wei Tseng, Han-Chieh Chao Li-Der Chou in Congestion Prediction With Big Data for Real-Time Highway Traffic discuss about the challenges faced when large amounts of data is processed. The data collection and processing is required in order to be able to efficiently analyse the data for information. Previous systems of big data processing used batch processing but this method cannot help us to achieve a useful real time traffic detection method. A real time traffic prediction model is proposed using Apache Storm and this is done through the analysis of large volumes of traffic streaming data. The data collected is data such as rainfall volume, traffic density, etc. This model is based on Support Vector Matrix and is used to predict the traffic congestion in Taiwan by collecting information from the Taiwan area national. Fuzzy theory is used to analyse the volume of traffic present in each section of traffic in real time. The final results of the model showed that prediction accuracy increased by 25.6%.

Zhaowei Qu ; Xin Wang ; Xianmin Song ; Zhaotian Pan ; Haitao Li in Location Optimization for Urban Taxi Stands Based on Taxi GPS Trajectory Big Data discuss how taxi stands are spread all over the city and their inefficient positioning leads to a lot of problems such as congestion and a waste of public space. This paper proposes a three step strategy to solve this problem. The most popular taxi hotspots are found using GPS and GIS technologies. The area which is required for these taxi stands are analysed and procured. The area that is allocated needs to be as optimal as possible. Then the demand between taxi stands and taxi stands is explored spatially. Finally with all the obtained information a taxi stand location model is constructed which encompasses the access cost of customers and the construction cost of taxi stands and hence the cost of optimized using this model. The results show that the proposed model could be useful in aiding the municipality to make optimal decisions regarding the placement of taxi stands around the city.

Dinithi Nallaperuma ,Rashmika Nawaratne ,TharinduBandaragoda ,Achini Adikari , Su Nguyen in Online Incremental Machine Learning Platform for Big Data-Driven Smart Traffic Management discuss that the technological landscape of intelligent transport systems (ITS) has been extremely transformed by the advent of the big data streams generated by the Internet of Things (IoT), social media, smart sensors, surveillance feeds, as well as growing infrastructure needs. It is necessary and important that ITS harness the potential of an artificial intelligence to develop the smart traffic management solutions for effective decision-making using big data techniques. The existing AI techniques contain clear limitations when it comes to processing the dynamicity of big data streams and the volatile traffic conditions. A smart traffic management platform (STMP) is built to address these problems based on the unsupervised incremental machine learning, deep learning, and deep

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reinforcement learning. The STMP combines the big data streams, such as the IoT, smart sensors, and social media to detect concept drifts and also to distinguish between the traffic events which happen recurrently and which are not so common and also to perform traffic flow forecasting.

Wenchao Xu , Haibo Zhou, Nan Cheng, Feng Lyu , Weisen Shi, Jiayin Chen, Xuemin Shen in Internet of vehicles in big data era discuss that vehicles these days in the modern scenario are equipped with radio access technology and have a massive amount of contact with the surrounding environment. Vehicular Ad-Hoc networks are rapidly developing their scale of application and conducting real time processing of data. They are evolving along with Internet of Vehicles (IoV) which have very promising future prospects. But vehicles keep increasing their consumption and production of data. This paper investigates the relationship between IoV and Big Data and further sees how IoV is facilitating the transmission, processing and storage of data. The applications of Iov in autonomous emerging vehicles is seen. In conclusion the future directions of IoV in Big Data are discussed.

V. BIG DATA ANALYTICS METHODS

Machine learning methods have helped us to enhance big data analytics better. Using various machine learning algorithms and methods in big data analytics have unlocked new methods to analyse and apply data to various applications. Using machine learning we can feed algorithms into machines and these algorithms program the computer to function better with problem solving and decision making methods. Using machine learning in big data analytics we can connect machines to large databases and facilitate their interaction. Using this interactions, future trends can be predicted. A machine learning model can improve the accuracy of the predictions that can be made in relation to big data. Hidden patterns and correlations can be discovered using machine learning algorithms. This will help us to enhance the existing system of ITS and also open new future enhancement opportunities.

A. Supervised Learning

In Supervised Learning, a function is mapped from the input to the output and for this another input output pair is used as an example. The pair has an object as the input and another object which is the target output that is required. A set of training examples are provide from which we can infer the labelled training data. Of all the supervised learning methods, the following are most useful for the field of ITS.

Linear Regression is used to predict the value of a dependent variable based on an independent variable. It finds a linear relationship between the two variables. Linear regression is popular because it is simple, easy to code and interpret and is also very robust. Although it is simple it is widely deployed among various ITS applications, like traffic speed estimation [9], etc.

A decision tree uses tree like graphs to come up with decisions and their possible consequences. Decision trees are robust, portable and transparent and hence are used in a variety of ITS applications such as the prediction of accidents and also the analysis of the severity of the accident [10].

Artificial Neural network (ANN) is very robust and flexible supervised learning. It can be implemented in both classification and regression. ANN can effectively learn the relations between the input data and the

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target data and then can be used to model the relations. It has been widely adopted in ITS as it can be used to model data. It is widely used in the prediction of the traffic flow and the travel time [11].

Support vector machine (SVM) is another popular algorithm which is used for the analysis of classification and regression. It builds a model which classifies the given data as either classification or regression. It is only applicable for labelled data. It has been used in ITS to predict travel time and accidents, automatic vehicle headlight switching systems [12].

B. Unsupervised Learning

Unsupervised learning method mainly uses unlabelled data. Here we allow the model to work by itself instead of supervising it actively. We can find many types of unknown patterns in the data. It also works in real time which is a very essential key feature in ITS as real time data is necessary for a lot of ITS applications. It also used the method of clustering which is used to find a pattern among unstructured data. K-means clustering is the most popular method used in ITS. K-means clustering finds centroids and then it allots the data to the cluster which is closest to it. It is widely used in ITS for the purpose of transportation planning and prediction.

C. Deep Learning

Deep Learning techniques are based on Artificial Neural Networks. It consists of multiple levels of processing to extract more and more information from the output. Deep Learning has been applied in ITS extensively. It has been integrated into various techniques and features of ITS in order to develop it further. It has been used to detect the mode of transportation using data obtained from vehicles [13], vehicle routing [14]. Traffic flow prediction, etc.

D. Ontology Based Methods

In all the entities that exist ontology is the naming, definition and inter relationship between them in a particular domain of discourse. Data semantics can be accurately described using ontology based methods and implicit data semantic relations can be inferred. A top down approach of data analysis is used here and data is mapped using heterogeneous methods. Ashish Singh Patel et al. [15] have proposed an ontology based multi agent bike sharing system using sensor data and video data. Fang Fang et al. have in their work proposed a model using ontology based methods for behaviour prediction of long time road users using semantic reasoning methods. [16].

VI. CONCLUSION

In this paper, we have first seen the various features of Intelligent Transportation Systems and about how it is possible for a large future scope. But the large volumes of data that it produces makes it difficult for us to analyze and process it. This is where we make use of big data analytics to process and store it. Various big data platforms such as spark, hadoop and sqoop are seen and the ways in which it can be implemented to process big data are discussed. Finally the various methods by which big data analytics can be implemented in seen. These methods mostly use machine learning algorithms to perform the required functionalities. These methods are used for various implementations such as traffic detection and planning, prediction of accidents, prediction of any congestions, geographical planning systems, etc. The future scope for big data analytics is massive and various applications can be implemented in order to enhance it further.

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