A Review on Role of Data Science in ayurveda based disease diagnosis using Prakriti type in Trividha pariksha

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Abstract — From past few years the digital world is revolving around data for its generation and effective utilization. Data Science is making it possible to generate needful information/ knowledge from the existing data to tackle different domain challenges. The evolution of Artificial Intelligence made Data Science more powerful and dynamic. Machine Learning and Deep Learning based Artificial Intelligence techniques are helping to get fast and accurate results. Data Science is gaining importance in Health Care domain because of its speed and accuracy which are much required for diagnosis of a disease at early stages. Ayurveda is an ancient medical system that is gaining popularity because of its trustworthiness and assured results. In Ayurveda, disease diagnosis depends on identification of Prakriti type. Trividha Pariksha is a method to identify the Prakriti and the disease. This study is presenting a review on the role of Data Science in Ayurveda based Disease Diagnosis using Prakriti type in Trividha Pariksha.

Keywords— Data Science, Artificial Intelligence, Machine Learning, Deep Learning, Ayurveda, Disease Diagnosis, Prakriti Identification, Trividha Pariksha.

1. Introduction

Data represents the raw facts of an object and are represented as a collection of variables. Structured data is collected as records and stored in the tables of a database. The stored data analyzed to generate information to answer the questions like: What was happened? How was it happened? Why was it happened? Later on, the generated information is used to gain knowledge to predict the future and to take the required steps. The data is of different kinds based on its scope, type, domain, etc. [1]. The decreased data rates, lowered hardware prices, increased mobile usage made the technology close to rural and novice users; made them to take the advantage of technology; resulting in a huge increase in number users [2] and data generation on daily basis. As per the information available in [3] the Internet is generating 500 million tweets per a day, 294 billion E-mails, 4PB through Facebook, 4TB from automated cars, 65 billion messages through WhatsApp, and more data through YouTube.   The estimated data by the end of 2025 is 463EB/day. This made the data big in volume, variety, velocity and veracity: Big Data. Covid-19 pandemic multiplied the volume of data. A new market research report shows that by 2027, the overall big data security market will grow to $64. 4 billion [4].
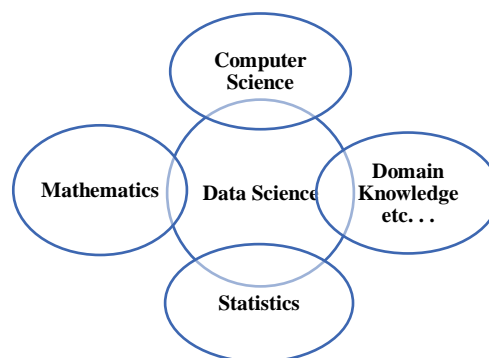

Figure 1: Data Science-Multiple Disciplines

Data science is an inter-disciplinary field that uses data analytics; scientific methods, processes, algorithms, systems by performing data

mining/data analysis to extract knowledge and insights from structured and unstructured data [5]. It includes multiple disciplines like mathematics, statistics, computer science, domain knowledge, etc., as shown in Figure 1.

The interconnection of Data Science, Data Analysis Process/ Knowledge Discovery in Databases and Data Analysis/Data Mining is depicted in Figure 2. Data Science is a big field of study of data; whereas Data Analysis Process/ Knowledge Discovery in Databases is the sub-field of it that concentrates on knowledge generation process and Data Mining/Data Analysis is one of steps involved in Data Analysis Process that actually generates the knowledge.

Data Analysis Process/ Knowledge Discovery in Databases (KDD) is the study of existing data and to generate required information and to gain knowledge from it. It is clearly explained by Fayyad and his colleagues in [6] that KDD process is divided into different steps or stages like, selection, pre-processing, transformation, data mining, and interpretation/evaluation. Data Mining/Data Analysis defines the methods that are used to extract knowledge from data. Data Analytics deals with the analysis of data using mathematical and statistical methods or algorithms. As the data is growing the methods used in KDD process become slow and error-prone. This led to the development of Big Data Analytics.
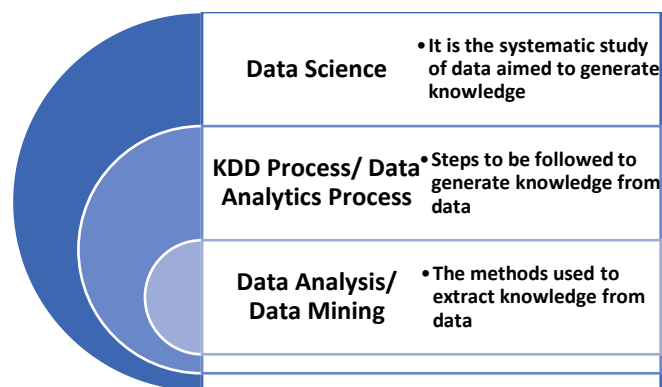

Figure 2: Data Science – KDD Process – Data Mining

To solve a data science related problem a well-defined procedure with a number of steps is required. In general, the procedure contains steps like: Identification of the problem, data collection, data preparation, exploratory data analysis, building a model, visualization of results, deployment and maintenance of the model. The general procedure followed to solve a data science related problem is presented in Figure 3.

The KDD process takes more time as it contains many steps and works to complete the given task. To increase the efficiency and to speed up the process the need for Artificial Intelligence is required. The advent of Artificial Intelligence filled the field of Data Science with new fuel. Data Science along with AI is trying to provide cost-effective treatment to middle-class people.
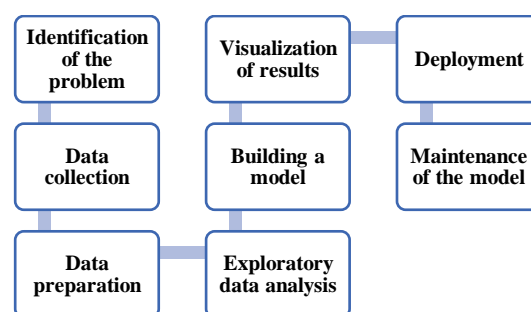

Figure 3: Procedure to solve a Data Science related problem

Ayurveda:

These days, Ayurveda is playing a key role in health domain. It is one of the most popular ancient medical practices. In this pandemic it has gained more focus and importance over the other medical practices. People are giving more importance to Ayurveda due to its 5000 years history, results and fewer side effects. Because of increased awareness on health care system and personal health, the people are getting attracted to ancient medical practices like Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homeopathy (AYUSH) [7].

The Ministry of AYUSH, Government of India is also giving importance for the development of AYUSH system of health care for its popularization, development and to make it as a preferred system for healthcare. In India the Ministry of AYUSH is dealing with all the activities like medication, drug manufacturing, research and development, telemedicine etc., relating to AYUSH. It is also gaining focus because of its way of treatment and assured healing in a natural way. It is providing solutions to different kinds of long-term diseases like diabetes, cancer, blood pressure etc., with fewer side effects [8].

In India, people use Ayurveda based medication in their daily life as home remedies. Before the allopathic kind of medication, the people are used to follow home remedies to cure cough, cold, skin problems and allergies, digestion like regular problems. It made the Indians to get familiarity and trust in Ayurveda. This familiarity/ awareness/ beliefs/ home remedies made Ayurveda to become a trusted system of health care. Allopathy system has its own importance in its aspect. But, the increased usage of allopathic medicines causing more problems in the form of side-effects; to cure these side-effects Ayurveda based health care system is preferred [9].

These days the health care industry is concentrating in providing Ayurveda based treatments to its customers. Many Ayurvedic hospitals were established and started providing treatment by following this ancient health care system. In this pandemic there is a huge increase in usage of Ayurvedic medicines. The pharmaceutical industry is also giving more importance to the manufacturing of Ayurvedic medicines. New medical practices like Integrative Medicine and Precision Medicine are also using Ayurveda based treatment as a part of their system.

Ayurveda-Dosha-Prakriti:

Ayurveda is the word derived from AYU(Life) and VEDA(Science). It is the science of life. It is having three branches: Nara Ayurveda – dealing with human beings, Satva Ayurveda – dealing with animals and Vriksha Ayurveda – dealing with plants. Ayurveda believes that positive health is needed for achieving four goals of life viz., Dharma, Artha, Kama and Moksha. Positive health is defined as: Well-balanced metabolism (Dosa Dhatu samya) and happy state of soul, senses and mind (Prasanna Atma, Indriya, Manah) [10].

In Ayurveda the human nature depends upon the natural constitution of body or Prakriti. It is determined at the time of birth and remains invariant throughout life. This Prakriti is determined based on three components (*tridosha*). These three functional elements represent the physical, mental and emotional energy patterns: namely, *Vata*, *Pitta* and *Kapha*. Vata is described as the energy of movement, Pitta as the energy of digestion or metabolism and Kapha as the energy of lubrication and structure. Like an individual with unique face, finger print, etc., he/she has his/her own Prakriti; a particular combination of Vata, Pitta and Kapha. If an individual maintains same Prakriti throughout his life then that individual is treated as healthy and if there is any change in Prakriti then that individual is treated as unhealthy. The changes in Prakriti may occur due to a number of factors like: stress, tension, improper diet, change in the environment, food, etc. The change in any one of tridosha leads to a disease or disorder. In Ayurveda an individual may belongs to any one of seven broad constitution types: Vata, Pitta, Kapha, Vata-Pitta, Pitta-Kapha, Vata-Kapha and Vata-Pitta-Kapha. Identification of Prakriti of an individual helps to diagnosis a disease in Ayurveda [11].

The rest of the paper is organized as: Section 2 describes about Artificial Intelligence and Techniques, Section 3 about Ayurveda based Disease Diagnosis, Section 4 describes about the Role of Data Science in Health Care Domain and Ayurveda, Section 5 details about Related Works in Ayurveda based Disease Diagnosis and Section 6 the Conclusion.

2. ARTIFICIAL INTELLIGENCE AND TECHNIQUES

Artificial Intelligence:

Artificial Intelligence (AI) is the trending technology that enables computers to mimic the intelligence of human beings. The advent of AI made data analysis easy by automating some/all steps involved in KDD process. AI is a way of programming that makes the computer, robot or a computer program to think, decide and react as a human. AI tries to solve a problem like a human being by programming the procedure that a human uses to solve a particular problem; It tries to automate the way of thinking, analysis, problem solving skills of a human being using computer programming. In early days the development is less and later on with the development of Deep Learning based techniques its importance was increased and is used in many domains to solve critical problems [12]. The evolution of AI is briefed in Table 1 [13].

Machine Learning/ Deep Learning:

Machine Learning (ML) is the subset of Artificial Intelligence and it is having the ability to learn automatically from existing knowledge without explicit programming. A mathematical/statistical model is created to do learning through training. Later on, the trained model is used to predict the outcome for the new data. The sub set of Machine Learning is Deep Learning (DL). This technique makes the computer/machine to learn the things

like human brain. It takes lots of data and filters the data through different layers. It performs automated feature extraction. With Deep Learning we are able to develop machine models for typical problems. The relationship that exists among AI, ML and DL is represented in Figure 4 [14].

Table 1: A Brief History of AI [13]

| Years	AI Era	Enabler	Problem solved	Limits
1980s	Rule-based "Expert Systems"	Databases	A few business functions	Brittle, expensive, no learning
Late 80s	First Neural Networks	Faster processors	Character recognition	Not scalable
2000s	Bayesian systems	Big Data, Hadoop	Search, speech recognition, chess, drones	Not actually learning? Climbing slope vs finding new slope
2010s	Deep Learning/ CNN	Bigger Data + GPUs/TPUs + Tensorflow	Computer vision, Natural language, Go, Cars	Trustworthiness
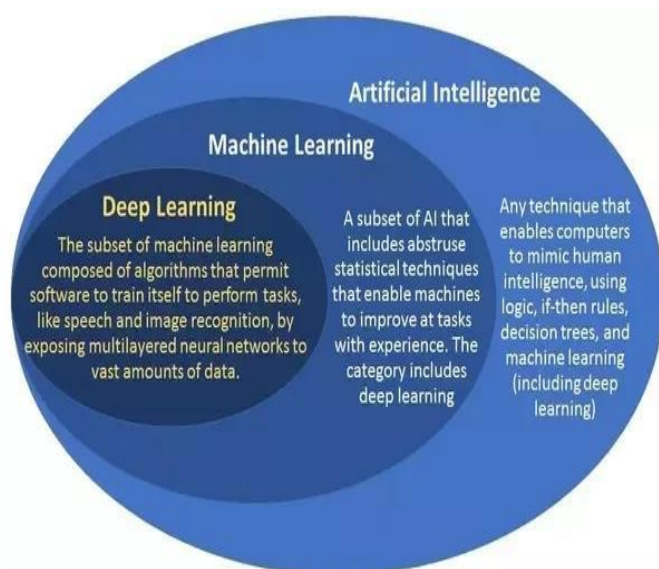
Figure 4: AI - ML – DL [14]

3. AYURVEDA BASED DISEASE DIAGNOSIS

Disease Diagnosis in Ayurveda is dependent on the Prakriti. The Prakriti can be identified through: direct observation or Nadi Pariksha/ Pulse Diagnosis or by following a questionnaire-based approach. AI based algorithms are helping to automate the identification of Prakriti. In Ayurveda a disease is diagnosed based on the Prakriti-Doshas (vata (V), pitta (P) and kapha (K) or their permutations). Based on the Prakriti the Practitioner has to prescribe the medicines or treatment. To identity the Prakriti the Practitioner has to gather information of the patient by asking different questions.

In Ayurveda to assess the disease and the strength of a patient Ayurvedic test/ Pariksha is conducted. There are different types of methodologies used to conduct Pariksha: Dvividha Pariksha (Two fold examination), Trividha Pariksha (Three fold examination), Sadvida Pariksha (Six fold examination), Ashtasthana Pariisha (Eight fold examination) and Dashavidha Pariksha (Ten fold examination). Trividha Pariksha (Three-fold Examination) is one of the Ayurvedic tests/ Parikshas used to examine an individual to identify his prakruti and to diagnose the disease. It examines an individual in three stages: Darsana Pariksha (Direct observation), Sparsana Pariksha (Examination by touch) and Prasna Pariksha (Examination by asking questions) [15]. In general, Darsana Pariksha is done by direct observation of the individual by the practitioner; Based on his physical appearance the practitioner

would identify his Prakriti type and his health condition. Sparsana Pariksha is done by performing Nadi Pariksha, an ancient non-invasive method and is subjective in nature; by placing index, middle and ring fingers on the radial artery the practitioner tries to examine the individual. Prasna Pariksha is done by asking a number of questions relating to his health, background, environmental details, etc., the practitioner would try to understand the condition of the individual. To perform these tests an expert Ayurvedic practitioner with good knowledge and skill is required. As the number of experts is less than the required, Data Science with Artificial Intelligence can help in to fill the deficit [16].

In Data Science, AI based techniques are used to automate: Darsana Pariksha with Computer Vision; Sparsana Pariksha by using AI integrated IoT based pulse diagnosis system or AI integrated optical sensor-based pulse diagnosis system; and Prasna Pariksha by creating machine models based on questionnaires.

4. DATA SCIENCE IN HEALTH CARE DOMAIN AND AYURVEDA

Data Science is used in different domains for different purposes and its need and importance is more in healthcare domain. Data Science is playing an important role in our daily life for finding an alternate medical system to Modern medical system. As per [17] there is a large scope for research in healthcare domain and there are many challenges to be addressed in health care domain like: getting qualified data to build efficient machine models, problems relating to

data usage among different areas, limitation imposed by regional laws, and procedure for getting approvals, etc. In health care domain there exist different kinds of data. It can be used to perform different kinds of research to improve the health care system in the world and As mentioned in Table 2, different kinds of data are generated in healthcare domain: *numeric data* generated by blood reports, *categorical data* generated through medical tests, *text data* generated by medical reports, video data generated from CT/MRI and Ultra Sound output, *speech/audio data* generated from doctor/technician's discussions and instruction *image data* from X-Ray and *signal data* generated from ECG/EMI signals. The available data types along with their applications are listed in Table 2 [17].

Table 2: Types of data and health care applications [17]

Type of Data	Healthcare Data	Preprocessing steps to use DL	DL based Healthcare Application
Numerical	Blood reports	Normalization of the data	Classification of normal/ abnormal
Categorical	Medical test results	Encoding	Classification of normal/ abnormal
Text	Medical reports	Word2Vec, TF/IDF, ELMO kind of word embeddings	Automatic Report generation, Summarizing medical report
Image	X-ray	Image Normalization	Classification, Segmentation
Video	CT, MRI, Ultrasound output	Slices/frames, image level preprocessing	Classification, Segmentation and object detection
Speech	Doctors and technicians discussions and instructions	Speech to text conversion	Capturing speech and generate report
Signals	ECG, EMG signals	Signals to vectors conversion	Classification of normal/ abnormal

Table 3 [17] lists different DL based algorithms for different kinds of health care applications. Convolutional Neural Network (CNN) is playing a major role in medical imaging [18] and also in decreasing time for clinical trials. ML and DL based Drug discovery is also reducing the time for new drug discovery [19].

In early days of AI, it is not used in health domain because of its erroneous nature. Later on, with the introduction of new algorithms like usage of Neural Networks has increased the importance, trust and accurate results AI gained importance in health domain. Health care domain is using AI in different aspects and making critical works as simple as possible. As mentioned in Table 3, AI can be used to provide personalized treatments, early detection of diseases, medical document translation, drug discovery, data augmentation, right treatment identification, etc. With AI many diseases like breast cancer, heart problems, PCOD problems, diabetes, etc., are getting diagnosed at early stages and helping the individuals to take precautionary measures.

Like AI based disease diagnosis done in Modern medicine, AI is also being used to do disease diagnosis in Ayurveda based medical system. As per [20-21] a ML algorithm can be used to predict the Prakriti based on the information given by the patient and making the task of the Practitioner easy. The ML algorithm is also reducing the number of questions to be asked by the Practitioner. It helps the people to identify their health problems in advance; take precautionary measures; avoid the upcoming health issue by making little changes in their routine life leading to a tension free life with no side effects. AI based techniques are also used for different purposes in Ayurveda like: Identification of Ayurvedic medicinal plants, Classification Ayurvedic Documents etc. The need for AI based models is more in the domain of Ayurveda as there is a less portion of research was done.

Table 3: DL based Algorithms for Health care Applications [17]

Type of DL	Specific Model/ Algorithm	Application in Healthcare	Examples
Supervised Learning	Feed forward networks	Personalized Treatment	Type 2 diabetes, cancer precision treatment
		Population Health	Predict malaria outbreaks
Convolutional Neural Networks (CNN)	CNN	Radiology – Image classification	Detecting healthy vs cancerous tissues to help improve radiation treatments, Chest TB classification
	CNN with Multi Task Loss	Organ segmentation in radiology	Lung segmentation
Recurrent Networks	Long Short Term Memory (LSTM)	Early warning	Sequence of parameters monitored to detect early the disease
	LSTM, Gated Recurring Units (GRU), Transformers for sequence modeling	Precision medicine	Dosage of BP level

	Neural Machine Translation with Seq2Seq models, Attention networks	Medical documents translation	Documents, medical transcription, translation to local languages
Unsupervised Learning	Auto encoder	Drug Discovery	Specific drug validation
Generative Adversarial Networks (GANs)	AC-GANs, DCGAN, cGAN	Data Augmentation	Class specific data generation
Reinforcement Learning	Deep Q Network	Right treatment identification	Sequence of treatment for cancer, HIV

5. DATA SCIENCE IN AYURVEDA BASED DISEASE DIAGNOSIS AND RELATED WORKS

In Data Science, ML/DL based machine models are trying to fulfill the deficit of experienced Ayurvedic medical practioners. The AI based machine models are aiding the practitioners in providing personalized treatment to people with ease and confidence. Different AI models were proposed by different researchers to automate the process of disease diagnosis in Ayurveda. The machine models were developed/ proposed to automate three phases of Trividha Pariksha: Darsana Pariksha, Sparsana Pariksha and Prasna Pariksha. The works relating to Ayurveda based Disease Diagnosis were reviewed and briefed in following paras.

Gayatri Gadre [22] has developed a computer vision-based facial recognition model for the identification of Prakriti by analyzing the facial features of an individual like hair, eyes, nose, lips, skin color, etc., by using image processing in Ayurveda. She used the Celebrity-Face-Recognition-Dataset to train and test her model. The dataset was labelled manually with the help of an experienced medical practitioner. She was success in identification of Prakriti based on facial features. She also stated that further research can be made by analyzing the texture of skin, hair, complete body, etc., to get more accurate results. Further, it was stated that more accurate results can be generated by integrating this computer vision based Prakriti identification with other two approaches: pulse based and questioner based Prakriti identification.

P. Venkata Giri Kumar, Sudheer Deshpande, H.R. Nagendra [23] have studied and detailed the relevance of pulse wave analysis with Nadi Pariksha. Pulse wave analysis has more importance in cardiovascular disease diagnosis. The qualities or properties of pulse such as pulse movement (gati), speed of the pulse (vega), stability of the pulse (sthiratva) and hardness of the artery (kathinya) play major role in NadiPariksha, these properties were analyzed and compared with the modern pulse parameters namely pulse wave velocity, pulse rate variability and arterial stiffness. Sensing of pulse can be done from eight locations: *two at radial artery, two at ankle, two at neck region and two at nasal region.* In Ayurveda the practitioners generally use the pulse palpation from the three fingers, namely, index, middle, and ring, placed on the radial artery at the wrist to identify the Prakriti.

R. R. Joshi [24] had presented a computational model of nadi patterns using quantitative estimation of tridosha. The pattern of nadi depends based on the level of tridosha. At some points three distinct patterns were observed based on the levels and tendency of vath, pitta and kapha; e.g., while observing the nadi patterns on jivanadi (radial artery), a snake curved scrawling is observed when there is high level vath; a frog's jump is observed when there is a high level of pitta; a pigeon's or swan's smooth and slow movement on rise of kapha. The variations in the levels of tridosha causes changes in frequency, shape, regularity, thickness etc., in the waveforms. So, the nadi patterns can be used as a quantitative measure of tridosha.

Sharoni Narang et al. [16] had proposed a method to automate Ayurveda based three-fold diagnosis test (Trividha Pariksha). In Sparsana phase the patient pulse was taken with the help of optical sensors and the data was fed to ANN to detect the Prakriti based on 3 different pulse signals relating to Vata, Pitta and Kapha. The training dataset was labelled with the help of Ayurvedic doctors. For implementation of the remaining two phases: darsana and prasna;the authors have collected the required data in the form of Questioners and placed in MySQL database. The work was done particularly for the diagnosis of Anemia and Hyperacidity. They used two different decision trees to predict these two kinds of diseases. The proposed system can be enhanced for more kinds of disease and for more accuracy.

Bhushan U Bawankar et al. [25] had proposed an IoT based patient monitoring and disease prediction system using Nadi Pariksha. The proposed system registers the patient and pulse sensors are attached to the arm of the patient, the pulse data is fetched for pre-processing on cloud securely; later on, a classification algorithm is applied for detection and validation of the results will be carried out.

Tiwari. P et al. [26] details a computational framework for predicting Prakriti classes from phenotypic attributes and is useful in precision medicine for stratification of endophenotypes in healthy and diseased populations. In predictive, preventive, personalized and participatory (P4) medicine uses endo-phenotyping along with omics approaches for identification of groups that differ in susceptibility, prognosis and therapeutic requirements. By using supervised modelling there is a reduction in number of features and questions required for Prakriti prediction.

V. Madaan and A. Goyal [27] had proposed a ML based model to predict the type of Prakriti (Human Body Constitution) by using ensembled learning techniques; and hyper parameter tuning was done for accurate results. The authors tested the data by using different ML techniques and proved that the ensemble learning techniques are more efficient way of prediction of the Prakriti. The authors used a well framed questioner composed of 25 questions to predict the type of Prakriti. The data was collected from end users and validated by Ayurvedic practitioners.

Andrew Stranieri et al. [28] has proposed a visual grid to digitally record an Ayurvedic Prakriti assessment as a first step to maintain integrated health records. They explained the need to maintain Electronic Health Records (EHR) in Ayurveda based medical system. They proposed a mobile application that helps a clinician and a patient to maintain a record the health information. By using this application, a clinician can record the dosha levels by using an interface with three scales and the data can be stored and shared. This app can act as a trigger for the organic evolution of EHR. In this app, a Maxwell triangle with smaller triangles isused to represent tridosha levels of a patient that helps in easy and fast diagnosis of diseases.

Clayton Bell1, R. Eric Heidel et al. [29] tried to find correlations between Ayurvedic Prakriti and active diagnosis. This might help the people with poor background who are unable to bear the cost of cost-effective diagnosis process. They used a 10 question Mind-Body survey to determine the Prakriti of the person. A medical history form with 47 commonly diagnosed medical conditions was given to the patients to know their health condition. Later, the data is analyzed to identify the correlations between Ayurvedic Prakriti and active diagnosis. They discovered multiple statistically significant positive and inverse correlations.

6. CONCLUSION

In Ayurveda, AI based machine models are automating the identification of Prakriti type and also the type of disease leading to a speed and accurate diagnosis. The developed or proposed machine models are automating one or two phases of Trividha Pariksha for Prakriti identification. Automating all three phases gives more accurate results for Prakriti Identification. After Prakriti identification the disease should be identified and treatment is to be provided. Machine models can be developed for disease identification and for required treatment. More models are needed to automate all these works, and more light should be focused on these areas in Ayurveda.

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