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AN INVESTIGATION ON THE ARCHITECTURE OF PUBLIC HEALTH INFORMATION SYSTEM BY USING ARTIFICIAL INTELLIGENCE

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Abstract

The development of public health information systems is crucial in addressing global health challenges. The advancement of artificial intelligence (AI) has opened up new opportunities for designing and improving public health information systems. In this study, we investigate the architecture of public health information systems using AI. We explore the potential of AI-based technologies such as machine learning, natural language processing, and computer vision in enhancing the efficiency, accuracy, and accessibility of public health information systems. We conduct a comprehensive review of existing literature and identify key challenges and opportunities associated with integrating AI in public health information systems. We also present case studies of successful implementation of AI-based public health information systems in various contexts. Our findings suggest that AI has the potential to significantly enhance the architecture of public health information systems and improve the quality and accessibility of health information for the general public and healthcare professionals. However, there are also challenges such as data privacy and ethical concerns that need to be addressed in the development of AI-based public health information systems. Overall, this study highlights the importance of integrating AI in public health information systems and provides insights into the potential benefits and challenges of AI-based technologies in this domain.

Keywords: Artificial Intelligence, Health Information, Investigation, Architecture, ML in Healthcare,

1) INTRODUCTION

In recent years, the role of Artificial Intelligence (AI) in public health has become increasingly important. With the advent of large-scale data collection and advanced analytics techniques, AI is poised to transform the way public health information systems are designed and implemented. This investigation aims to explore the architecture of public health information systems, focusing on how AI can be integrated into these systems to improve their efficiency, effectiveness, and accuracy. The study will examine the various components of a public health information system, including data collection, storage, analysis, and dissemination, and identify areas where AI can be used to enhance each of these components. The investigation will also analyse the challenges and opportunities associated with the integration of AI into public health information systems. This will involve assessing the technical, ethical, and regulatory considerations that must be taken into account when implementing AI-based solutions in the public health domain. Overall, this investigation seeks to contribute to the growing body of research on the role of AI in public health, and to provide insights and recommendations that can inform the design and implementation of effective and ethical public health information systems in the future.

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a. Architecture of Smart Health System Using Artificial Intelligence

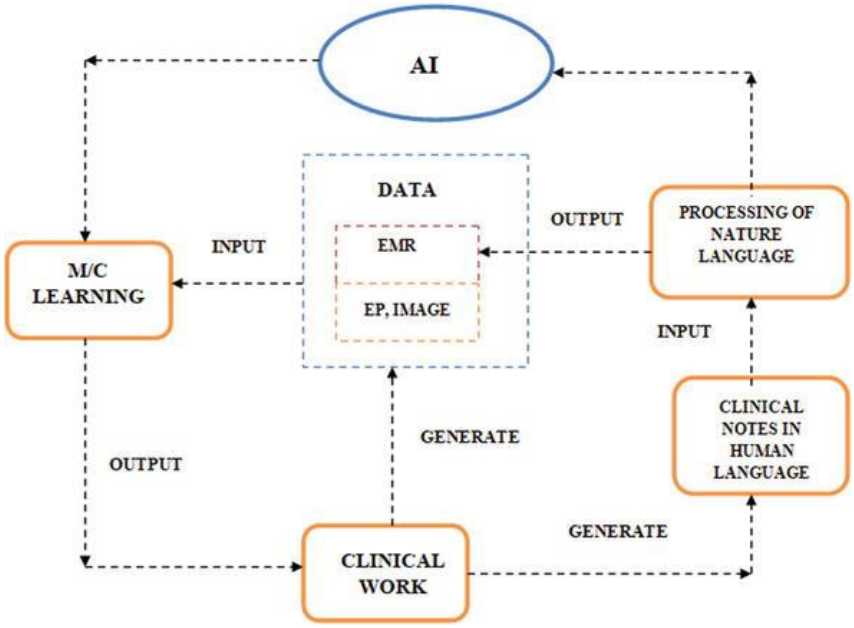

Figure 1: Architecture of healthcare using AI [1]

Figure 1 portrays the proposed architecture for shrewd healthcare frameworks that utilization man-made intelligence to help doctors, patients, medical attendants, EMS, drug specialists, and radiologists. How those entertainers are acquiring such help is portrayed in the segments that follow:

- Patient: Emergency clinics involving this architecture for savvy healthcare frameworks will give every one of its recorded patients a sensor-based remote device to screen their advancement. This contraption will naturally refresh the patient's everyday information in a unified data set framework, whether it is introduced at home or at a clinical office. In view of the patient's information, simulated intelligence will simply decide, and if essential, Crisis Clinical benefit (EMS) will be sent.
- EMS: Crisis Clinical benefits EMS might find utilization for sensor-based contraptions that are consistently in the patients' hands. Computer based intelligence assists EMS with deciding and gives crisis care to extremely sick patients, like stroke casualties. To screen the patients' circumstances and give speedy assistance to a short timeframe, simulated intelligence based algorithmic PCs demand various data sources, for example, temperature, circulatory strain, etc.
- Medical caretakers: Without having to physically include the information, attendants can oversee huge volumes of patient information with the utilization of astute man-made intelligence-based contraptions. The artificial intelligence-based framework, which gets patient information from their shrewd gadgets, keeps medical caretakers up to current

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consistently. Simulated intelligence helps medical attendants in surveying sickness condition and planning for impending mediations.

- Specialists: simulated intelligence smooth out the entire interaction by monitoring patients, screening them, and supporting quick decisions. Computer based intelligence can rapidly change unstructured information into coordinated structure, delivering exact discoveries and empowering the most dependable determination. Computer based intelligence created radiologist reports, clinical research center discoveries, and numerous other choices emotionally supportive networks are utilized to help specialists. Artificial intelligence might be utilized by specialists to inspect basic patient records and medical caretaker patient discussions. Besides, it empowers clinicians to handle issue districts before they become ongoing sicknesses by recognizing the impacted regions that bring down patients' personal satisfaction.
- Radiologists: artificial intelligence helps radiologists in the identification and checking of ailments. Concerning position including picture distinguishing proof, artificial intelligence frameworks have gained remarkable headway. The significant administrations presented by computer-based intelligence are assessments of radiological charts and picture acknowledgment of mind-boggling designs. Fresher man-made intelligence applications might uncover the impacted part in more detail than should be visible with the unaided eye by distinguishing the paediatric bone age known as RSNA. Being the most common and hazardous sort of danger, cellular breakdown in the lungs requires speedy distinguishing proof and care. Finding the pneumonic knobs requires evaluating for cellular breakdown in the lungs. Artificial intelligence (computer-based intelligence) can perceive knobs and characterize them as harmless or dangerous. The extensive strategy of mammography screening is a critical trouble for most of radiologists.

b. Several AI Systems That Are Relevant to Healthcare

Truth be told, there are various innovations that make up artificial intelligence. While most of these advancements are promptly relevant to the healthcare business, the exact techniques and occupations they help contrast extraordinarily. Here are definitions and depictions of some particular man-made intelligence advancements that are vital to healthcare.

- **Deep learning and neural networks in machine learning**

AI is a measurable strategy for 'learning' through 'instructing' models with information and fitting models to information. One of the most predominant sorts of computer-based intelligence is AI; in a 2018 Deloitte survey of 1,100 US supervisors whose associations were at that point investigating man-made intelligence, 63% of the organizations addressed were utilizing AI [2]. There are a few varieties of this wide procedure, which shapes the premise of numerous simulated intelligence systems. Accuracy medication, which figures out which treatment methods are probably going to be viable on a patient in view of various patient characteristics and the setting of the treatment, is the most well-known utilization of old-style AI in the healthcare business [3] by far most of AI and accuracy medication applications call

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this directed learning, and it requires a preparation dataset for which the end variable (such the start of disease) is known.

- **Processing of natural language**

Since the 1950s, artificial intelligence analysts have been attempting to comprehend how human language functions. NLP is a discipline that contains language-related applications including voice acknowledgment, text examination, interpretation, and others [4]. The two fundamental strategies are factual NLP and semantic NLP. Factual NLP depends on AI, explicitly profound learning brain organizations, and has assisted with further developing acknowledgment precision as of late. It needs a huge "corpus," or group of language, to learn.

- **Rule-based professional systems**

All through the 1980s and succeeding many years, master frameworks based on data sets of "on the off chance that" rules overwhelmed the field of artificial intelligence. Throughout the previous twenty years, they have been widely utilized in the healthcare business for "clinical choice help" reasons, and they are still every now and again utilized today. As a component of their frameworks today, numerous electronic health record (EHR) suppliers give a bunch of guidelines. [5].

- **Physical robots**

Considering that in excess of 200,000 modern robots are conveyed every year around the world, actual robots are right now notable. In settings like production lines and distribution centres, they do foreordained exercises including lifting, moving, welding, or collecting merchandise, as well as shipping supplies in medical clinics. All the more as of late, robots have worked on their capacity to cooperate with individuals and are easier to educate by having them do an ideal action. Likewise, they are creating more prominent intelligence as extra computer-based intelligence abilities are coordinated into their "cerebrums" (actually their working frameworks). It is conceivable that over the long run, similar headways in intelligence we have seen in different fields of computer-based intelligence would be applied to real actual robots [6].

- **Automating processes using robots**

This innovation executes coordinated computerized organization undertakings — those including information frameworks — as though they were being completed by a human client who was adhering to a bunch of directions or rules. They are less expensive, less complex to program, and more straightforward than different kinds of simulated intelligence. Mechanical interaction computerization (RPA) generally uses server-based programming instead of real robots. To act as a semi-smart client of the information frameworks, it relies upon a blend of work process, business rules, and 'show layer' joining. They are utilized in the healthcare business for routine obligations including invoicing, earlier approval, and patient record refreshes. They might be utilized to extricate information from, for example, faxed pictures to take care of it into value-based frameworks when matched with different innovations like picture acknowledgment [7].

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c. Healthcare AI Applications: Opportunities and Challenges

The market ought to fabricate frameworks for each particular field utilizing AI calculations with a critical number of cases that consolidate ethnic and social subtleties of patients to build the symptomatic precision of man-made intelligence applied frameworks [8]. While extra learning models are added by healthcare scholastics and specialists, such man-made intelligence frameworks might get savvier. The ramifications of clinical simulated intelligence frameworks incorporate both idealistic and tragic components, similar as any utilization of new innovation. The idealistic perspective offers various new chances to treat sicknesses all the more effectively, to convey better consideration and a superior patient encounter, to support patient contribution in their own consideration, to bring down clinical blunders and healthcare costs, and to help the administrative viability of healthcare suppliers [9]. However, the tragic perspective carries with it a large group of threatening new issues. The rising utilization of patient information for investigation might adversely affect employer stability clinical misstep responsibility and protection and security dangers [10, 11]. To guarantee a clever use of man-made intelligence and its broad reception in the healthcare business, we consider a few the key positive and negative perspectives related with the organization of man-made intelligence-based innovations ought to be contemplated.

Possibilities for AI Applications

The developing utilization of artificial intelligence-based innovation in the healthcare area has opened up a wide scope of new choices. The following are a portion of the essential ones covered.

- **More effective disease treatments**

The launch of IBM Watson marked a significant turning point in the field of data-driven medical research and sparked public interest in the potential advantages of using cutting-edge digital technology to improve patient care and public health [12]. Advanced technologies are becoming more and more crucial in enhancing medical professionals in practically every aspect of patient treatment, as detailed in the real-world instances of AI applications in healthcare. For instance, Dawes et al. [13] described how a magnetic resonance imaging (MRI)-based algorithm of cardiac motion backed by AI may be used to treat patients with high blood pressure and lung illness with more precise data. In the same spirit, 3Billion created an algorithm in 2019 to identify uncommon DNA-based disorders. AI-based technologies may significantly enhance patient care services in rural farming areas in developing countries, according to Guo and Li [14].

- **Increased patient involvement and engagement**

One of the most generally involved health instructing applications for cell phones, Noom, is an eating regimen programming that likewise serves as a convenient diabetes preventive program [15,16]. As per the business, "we work with clients all through the world to assist them with embracing better propensities, bring down their possibility creating ongoing health issues, switch sickness, and structure more grounded associations with themselves simultaneously"

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[16]. The way to arriving at the targets one sets while using this instructing programming is having major areas of strength for a to the game-plan. Precise disease analysis and patient wellbeing rely upon patient association in the clinical treatment process. Likewise, patients accept that their own contribution in gatherings with clinical experts is a useful and beneficial experience for themselves [17, 18]. Patients are bound to be totally associated with doing their piece of the cycle when they are urged to partake in their clinical treatment, which emphatically influences how fulfilled they are with the norm of care [19]. As indicated by Boulding etc. [20], the treatment result and patients' security are emphatically affected by patients' great encounters with their cooperation in the treatment cycle. Patient contribution and cooperation ought to in this manner be an essential point of healthcare experts to improve the patient experience as a technique for upgrading the nature of administration [21, 22].

- **Increased Service Quality and Medical Error Reduction**

As per Wang et al. [23], in China, clinicians who utilized artificial intelligence to help with colonoscopy tests found 20% a greater number of polyps than the people who didn't. The simulated intelligence upheld approach can distinguish beginning phase or exceptionally little (5 mm or more modest in size) polyps that numerous gastroenterologists ignore during colonoscopy assessments. Subsequently, artificial intelligence frameworks support doctors in eliminating possibly perilous little polyps, upgrading patient consideration, and bringing down the gamble of clinical blunders.

A computer-based intelligence framework based on clever calculations and request boundaries was said to have been created by an exploration group at the College of Tokyo Clinical School. The best precision rate found when this strategy was joined with a profound learning man-made intelligence clinical programming was 83.5% when applied to an example patient gathering. The precision rate increased to 87.3% [24] when the framework was coordinated with a profound learning and choice tree computer-based intelligence framework. Recently made savvy man-made intelligence frameworks can possibly additionally diminish botch rates and are expected to expand the nature of treatment gave.

- **Enhanced Operational Effectiveness and Lower Medical Expense**

As recently noted, numerous indicative errands might be taken care of by computer-based intelligence upheld clinical frameworks without the requirement for human support. For example, a monotonous old style upper endoscopy might be supplanted with a pill camera with man-made intelligence inserted to evaluate for stomach malignant growth. To evaluate for intense Escalante etc [25] fostered an original simulated intelligence-based method that might supplant the costly customary strategies by inspecting the properties of the bone marrow. The symptomatic and treatment systems are undeniably faster and savvier thanks to these simulated intelligence arrangements.

- **Enhanced Productivity and the Development of New Jobs**

Will artificial intelligence (simulated intelligence) and robots supplant all that people presently do? From the principal Modern Unrest to the fourth Modern Insurgency, the set of experiences

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and progress of modern development have shown that, notwithstanding the way that numerous normal manual undertakings were uprooted by innovation, various new positions were likewise made to help rising efficiency [26]. For example, despite the fact that the printed copy printing industry has radically declined, various new work in advanced altering and typography have arisen [27]. Then again, countless new positions were created to foster route and geographic information frameworks, while a few guide distributers shut their entryways.

- **Lower Medical Costs**

The ideal healthcare framework would incorporate information and proof-based ailment counteraction, state of the art innovative analysis and therapy, patient-driven custom fitted consideration, and top calibre, empathetic consideration from clinical experts. In the event that artificial intelligence can be broadly used to help such ideal healthcare, it might assist with guaranteeing both excellent healthcare and extensive expense decreases. ABI Exploration, a promoting research counselling organization, distributed a paper guaranteeing that by 2021, the US healthcare area might save $52 billion in light of the fact that to shrewd purposes of artificial intelligence (computer-based intelligence). Significant emergency clinics in the US and Israel are now utilizing simulated intelligence-based disease anticipation programs, as per ABI Exploration. In these two countries, it is guessed that the quantity of simulated intelligence upheld gadgets for patient preparation to stay away from persistent diseases, (for example, diabetes and hypertension) would ascend from 53,000 in 2017 to over 3.1 million by 2021, 176% yearly development. Consequently, man-made intelligence applications in healthcare can possibly essentially bring down clinical consumptions for both individual patients and society all in all. Those reserve funds may be utilized broadly to work on everybody's personal satisfaction by means of sickness counteraction.

Artificial Intelligence Applications' Difficulties

In spite of the fact that artificial intelligence applications give additional opportunities to improving individuals' regular daily existences, they likewise present troubles that should be effectively survived. The stakes in the healthcare business are especially high since lives are on the line. Coming up next are a portion of the troubles that should be overwhelmed with information [28].

- **Responsibility for System Usage**

On May 7, 2016, a Tesla Model S independent vehicle failed, killing an individual. The subject of "Who ought to be considered liable for the mishap?" must be tended to. Who ought to be considered responsible assuming that clinical labourers utilized simulated intelligence-based innovation to treat patients and a mishap or misstep happened? AI calculations made by people are the premise on which artificial intelligence-based applications work. The choice to procure the framework was made by clinic the executives with input from clinical faculty, innovation advisors, and subject matter experts. The strategy was utilized by emergency clinic clinical experts to give a patient the consideration they need. Thus, should the emergency clinic, clinical faculty, or framework configuration organization be considered responsible for the issue?

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Given the numerous mechanical, managerial, and moral contemplations included, this is an incredibly moving point to reply.

There has been next to no concentrate on the moral ramifications of man-made intelligence, in spite of the way that simulated intelligence related advancements are growing rapidly and having many purposes. Dr. Stephen Selling said that the world is quickly approaching a phase when human power would become unmanageable because of the fast improvement of simulated intelligence and canny robots. He said that we want to make another worldwide administering association to regulate the utilization of simulated intelligence [29]. Lupton [30] underlined the need to make moral and moral ways of behaving for artificial intelligence that benefit society as opposed to hurt it. Taking into account the utilization of artificial intelligence-based advances and frameworks is supposed to increment altogether later on, these frameworks ought to be made with human execution and society standards and values as a main priority. Responsibility for any adverse consequences of computer-based intelligence applications ought to be based on cultural arrangements, particularly in the field of progressive healthcare.

- **AI Divide**

The way that individuals frequently have total confidence in clinical laborers separates the healthcare area from other help organizations. This might be made sense of by a self-influenced consequence, which expresses that a clinical effect happens when a patient indiscriminately acknowledges a specialist's treatment and feels that their condition will be recuperated [31]. All in all, patient-doctor trust is fundamental since it upgrades the adequacy of treatment. The patient will be engaged with a consideration conveyance process that fosters an association with an artificial framework as opposed to a human specialist if a simulated intelligence-based innovation or framework takes the occupation of a specialist. Trust is likewise fundamental for the improvement of this new association between a patient and a simulated intelligence empowered gadget or framework [30]. In any case, it would be undeniably challenging for somebody who has never utilized computerized innovation, much alone artificial intelligence, to trust a machine. In the event that the specialist can console the patient about how the framework will permit the person in question to acquire better treatment, this man-made intelligence boundary could be crossed over.

- **Cyber security for Security and Privacy**

Since artificial intelligence put together innovations and frameworks depend with respect to gigantic datasets, protection worries around information assembling and sharing arise. Since patient records incorporate individual information, it is extremely hard to send and control infection related information across a few data sets [32]. This suggests that product designers should comply with secrecy regulations, which could give difficulties to the advancement of man-made intelligence. The dynamic course of artificial intelligence innovation depends on AI of the assembled information introduced, which makes moral, moral, and lawful worries since it dismisses the remarkable conditions of individual patients. Subsequently, it is imperative to discuss the regulations, ethics, and individual qualities that oversee how individuals act in the public arena and that simulated intelligence innovation ought to keep.

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- **Managerial Control Loss**

A few areas are not generally disengaged storehouses in the computerized age. There is no exemption in the healthcare area. Before, the healthcare business was considered where individuals went to have doctors and medical attendants treat their ailments. However, these days, as well as getting great clinical consideration, phenomenal health is the consequence of healthy way of life decisions including a fair eating regimen, regular work-out, and everyday prosperity rehearses. Preventive medication has in this manner become essential, and subsequently, the lines between a healthy way of life, drug, and innovation help have developed more cloudy [28]. Existence impediments might be defeated utilizing artificial intelligence. The regular thought of a shut healthcare framework is consequently presently not pertinent. For example, various cell phone-based applications (like Robot Maria, Alexa, simulated intelligence speaker Aria, and so on) may help with incorporating numerous features of an individual's prosperity. Artificial intelligence-based arrangements can remotely screen, analyse, treat, and oversee patients who are at home.

- **The Pain of Change, Training/Education Requirements, and Job Loss**

To plan for additional profoundly gifted positions in the artificial intelligence age, Amazon as of late expressed that it will reinstruct 100,000 labourers by means of preparing programs on new advancements by 2025. At the point when innovation modifies the manner in which individuals go about their responsibilities, they get the opportunity to advance their professions and advantage from those changes, as per Jeff Wilke, President of Amazon's worldwide buyer division [33]. An extra model is the Health Development Large Server farm at Asan Clinical Center in Seoul, Korea, which has recently begun schooling programs for future simulated intelligence experts who can make and market computer-based intelligence calculations. [34].

d. Recent Advances in Artificial Intelligence-Based Health Services

With its state-of-the-art developments, computer-based intelligence has shocked the globe, and everybody in the clinical field is endeavouring to embrace it. Numerous new progressions that will be incorporated into the proposed structure are recorded underneath, including qXRfor TB screening, qER for head CT checks, qScout-EMR, Moving ARM, and Google artificial intelligence for tracking down bosom threatening developments:

a) Qxr for TB screening

The qXR device examines chest X-rays for evidence of pleural, hilar, and pneumonic TB.Both the conventional essential pneumonic TB and its abnormal side effects can be tracked down utilizing qXR's artificial intelligence calculation. It can at the same time evaluate for diseases remembering cellular breakdown in the lungs for high-risk people, COPD, and different heart sicknesses notwithstanding its tuberculosis utilizes.

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b) Qer tool for Head CT scans

Following figure(s) demonstrates the way that this instrument can recognize, limit, and survey the seriousness of an assortment of frontal cortex infections, for example, a wide range of intracranial passing, midline shift, mass effect, infarcts, and cranial cracks. Table 1 gives the precision.

Table 1: The precision of every algorithm

Abnormal Findings	AUC (confidence interval)	Specificity	Sensitivity
Intraparenchymal Haemorrhage	1.97	1.89	1.10
Extramural Haemorrhage	1.80	1.88	1.20
Intracranial Haemorrhage	1.99	1.90	1.10
Subarachnoid Haemorrhage	1.99	1.90	1.10
Intraventricular Haemorrhage	1.99	1.93	1.98
Cranial Fracture	1.97	1.96	1.11
Infarct	1.96	1.99	1.89
Midline Shift	1.95	1.98	1.99

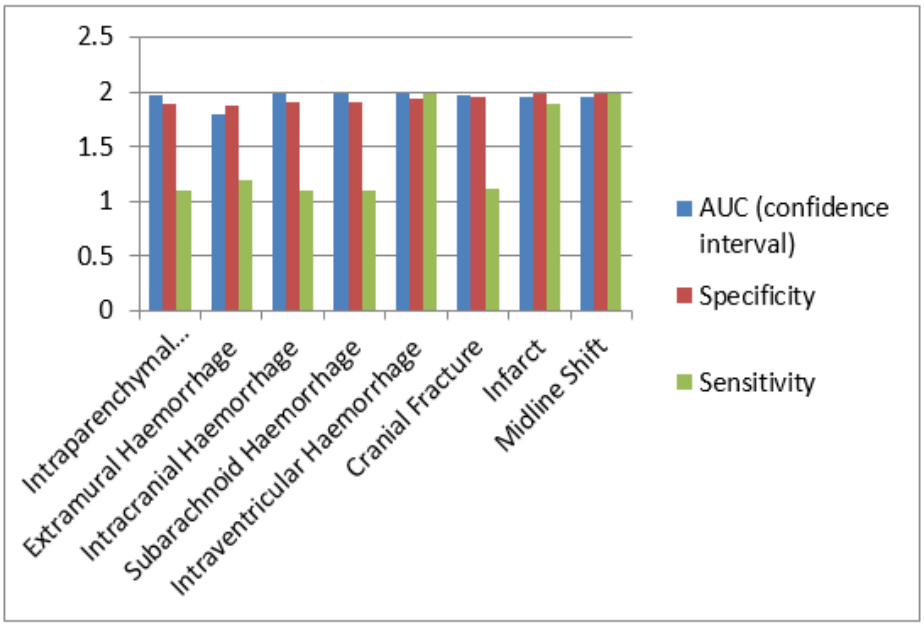

Figure 2: The Precision of Every Algorithm

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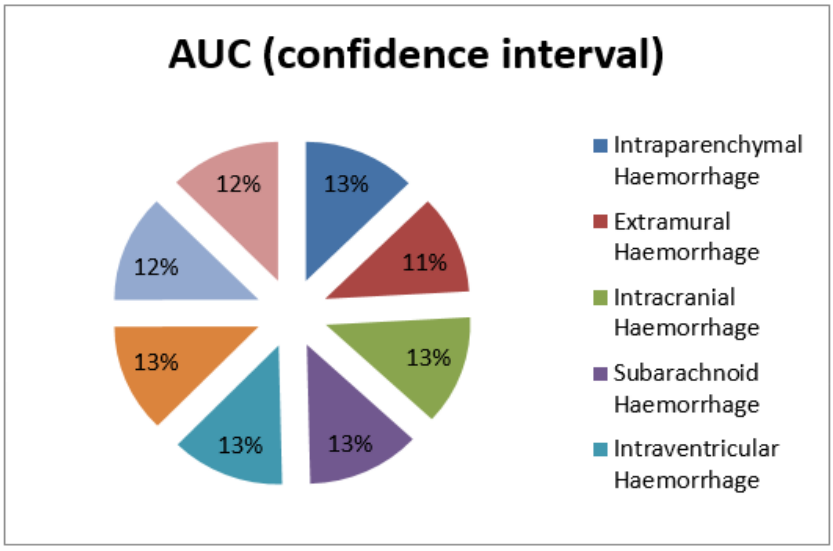

Figure 3: The Accuracy of Each Algorithm

2) MATERIAL AND METHOD

The COVID-19 dataset for India was gathered from the PRS Legislative Research dataset for June 1, 2020, and November 31, 2020. Each state and Union Territory's humidity and temperature data were obtained from TuTiempo.net, which offers the researchers a significant volume of worldwide weather data. The State-wise population density data were collected from the 2011 census of India, which was available online at https://www.census2011.co.in. Information on the senior populace and Gross domestic product per capita were assembled from the service of measurements and program execution's true site. The life expectancy, poverty rate, and urban population data are gathered from [35]. The data on hospital bed availability is accessible from the official website of the center for disease dynamics, economics & policy.

A. Logistic Growth Model

The COVID-19 growth rate during the unlock phase for each state in India was determined by a logistic growth model. The rate of change in total reported coronavirus infected cases was fitted using a logistic growth model to the number of infected cases per day. In order to do this, the least-square fitting technique was used. In mathematical epidemiology, when using the logistic model, the following equation can be used to define the growth of the number of cases over time:

$$\frac{dc}{dt} = rc\left[1 - \frac{c}{k}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

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Where c is the total number of infection cases over time t, r is the disease growth rate, and K indicates the final pandemic size the solution of (1) is:

$$c = \frac{k}{1+\left[\frac{k-c_o}{c_o}\right]exp^{-rt}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(2)}$$

Where $c0$ denotes the number of cases at the initial stage.

The change in total cases determined using a seven-day rolling average of infected cases is as follows:

$$l_t = c_{t+t} - c_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(3)}$$

B. Spatial Autocorrelation Analysis

The spatial autocorrelation analysis determined how a unit's value has a spatial correlation with the surrounding unit's values. Because the statistics relied exclusively on studies independent of one another, spatial autocorrelation was evident. If autocorrelation occurred in a map, it ruled out the possibility of the studies being independent of one another. The Worldwide Moran's Record (GMI) was utilized to quantify worldwide spatial relationship, while the neighbourhood marks of spatial Affiliation's Nearby Moran's File (LMI) was utilized to gauge nearby geological connection. The spatial autocorrelation study was performed using the ArcGIS software's spatial statistics and pattern analysing tool. We ran the spatial autocorrelation analysis in ArcGIS using the default parameters.

$$\boldsymbol{Global\ Moran's\ I} = \frac{\boldsymbol{n\Sigma_{i=1}^{n}\Sigma_{j=1}^{n}W_{ij}(X_i - X)(X_j - X)}}{\boldsymbol{\Sigma_{i=1}^{n}\Sigma_{j=1}^{n}W_{ij}\Sigma_{i=1}^{n}(X_i - X)^2}},$$

$$\boldsymbol{Local\ Moran's\ I} = \frac{\boldsymbol{n(X_i - X)\Sigma_{j=1}^{n}W_{ij}(X_j - X)}}{\boldsymbol{\Sigma_{i=1}^{n}(X_i - \bar{X})^2}}.$$

Wij is the spatial load between highlights I and j, Xi is a trait's disparity from the mean for include I and n is the all-out number of elements. The worth of the worldwide Moran's I goes between [-1,1]. The appropriation shows a capricious example when the file is near nothing. Assuming the file is near - 1, the dissemination is scattered, and in the event that it is near 1, it is bunched. In light of Neighbourhood Moran's, I calculations, the LISA accumulation might group the development rate dissemination into two classifications of positive connections: Low (LL) and High (HH); two classes of negative relationships: Low-High (LH) and High-Low (HL); and non-critical relationships. Positive connections suggest that the development rate is in accordance with the pattern that has been found in the area.

C. Geo-Detector Method

The Geo-detector approach may quantify and assess the importance of stratified spatial heterogeneity. Geo-Detector's sub-detectors are factor detector and interaction detector.

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The q value is used to express factor detection, i.e. the relative importance of explanatory variables, and its formulations are as follows:

$$q = 1 - \Sigma_{h=1}^{L} N_h \sigma_h^2 / N\sigma^2 = 1 - SSW/SST,$$

$$SSW = \Sigma_{h=1}^{L} N_h \sigma_h^2 ,$$

$$SST = N\sigma^2 .$$

Where Nh and σ^2 stands for the number of units and variance of observations within the $h\ th$ (h = 1, 2 …, L) study region N and σ_h^2 denotes the number of units and variance of the observations in the total study region SSW denotes the weighted sum of local variance SST represents the weighted sum of global variance. The interaction detection can determine whether the independent variables can improve the explanatory power of the dependent variable when they work together, or their effect on the dependent variable is independent of each other. It can identify whether there is an interaction between the two variables, how 71 strong the interaction is, and whether the connection is linear or non-linear. Compared to traditional statistical approaches, the Interaction detector has a significant benefit in distinguishing the q values, i.e. (($X1$) and ($X2$)) to the interaction q value, i.e. (($X1 \cap X2$)). The q value represents the capacity of interactions of two independent variables to explain the dependent variable.

3) RESULTS

A. Spatial And Temporal Spread of Covid-19 Growth Rate

As shown in Table 2, the nationwide average growth rate decreased from June to November 2020. In June, the average growth rate was 0.113, and in November, it was 0.024. The highest level of growth rate between June and November 2020 was among the eastern states of India. The growth rate's coefficient of variation varied from 123.751% to 71.525%. After June 2020, the differences in growth rate among different states were small, with the coefficient of variation below 72%.

Table 2: COVID-19 growth rate descriptive statistics from June to November 2020

	Jun	Jul	Aug	Sept	Oct	Nov
Min	0.016	0.011	0.007	0.018	0.008	0.0009
State/UT	Chandigarh	Ladakh	Delhi	Manipur	Mizoram	Dadra and Nagar Haveli
Max	0.787	0.145	0.132	0.085	0.085	0.058
State/UT	Sikkim	Meghalaya	Nagaland	Chandigarh	Meghalaya	Arunachal Pradesh
Mean	0.113	0.053	0.047	0.044	0.042	0.024
Standard Deviation	0.140	0.026	0.0242	0.017	0.018	0.017
Coefficient of variation	123.751%	50.346%	51.324%	39.203%	42.696%	71.525%

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B. Analysis of Factor Detection

The q upsides of the multitude of factors breezed through the importance assessment at the 5% level, exhibiting their high capacity to figure the geographic appropriation of the Covid pandemic spread. Specifically, the upsides of q(p) for the accompanying factors were equivalent: temperature, populace more than 60, populace thickness, metropolitan populace, Gross domestic product per capita, destitution rate, future, and medical clinic beds accessible. 0.021(0.003), 0.15(0.000), 0.17(0.000), 0.01(0.002), 0.08(0.000) ,0.04(0.001), 0.01(0.006) and 0.072(0.001) respectively. Nevertheless, population density, population aged 60 and above, GDP, and hospital beds available had a comparatively high impact and can explain 16.86%, 14.92%, 7.90%, and 7.20% of the variance, respectively

C. Analysis of Interaction Detection

The COVID-19 growth rate is affected by the interaction between two independent factors, as seen by the interaction detector.

Table 3: q Value of Variables Interaction Effect on Covid-19 Growth Rate

	T	Age>=60	PD	UB	GDP	PR	LE	HB
T	0.021							
Age	0.19	0.15						
PD	0.23	0.45	0.17					
UB	0.05	0.19	0.22	0.01				
GDP	0.12	0.3	0.32	0.19	0.08			
PR	0.12	0.20	0.22	0.07	0.16	0.04		
LE	0.03	0.19	0.2	0.03	0.12	0.07	0.1	
HB	0.14	0.22	0.25	0.14	0.24	0.16	0.12	0.072

*T, age>=60, PD, UB, GDP, PR, LE, and HB represents Temperature, Population aged 60 and above, Population Density, Urban Population, GDP per capita, Poverty Rate, Life Expectancy, Hospital Beds available, respectively

Table 4.3 shows the q value of interaction was greater in Population density ∩ elder population (0.45), Population density ∩ GDP (0.32), GDP ∩ elder population (0.3), Population density ∩ Hospital beds available (0.25), and GDP ∩ Hospital Beds (0.24)

D. Correlation Analysis of Exploratory Data and COVID-19 Growth Rate

After performing VIF analysis, the humidity covariate was removed from the multiple linear regression models. Table 4 report the results from data fitting using the multiple linear regression models to the covariates. The adjusted R-squared and multiple R-squared values for the model were found to be 0.731 and 0.791. These statistics show that the model has an excellent explanatory capacity. The percentage of the older population, population density, poverty rate, and humidity positively correlate with the growth rate. On the other hand, the Urban Population, Life expectancy, total hospital beds, GDP, and temperature negatively correlate to the growth rate. Table 4 shows that, among all the covariates, GDP (p=0.001) was the most significant variable, followed by the percentage of the older population (p=0.011), average temperature (p=0.018), and life expectancy(p=0.038).

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Table 4: Statistical Summary of Multiple Regressions

Variables	Coef	Std err	t	P>|t|
Population density	0.532	0.0262	2.028	0.052
Older percentage	0.0078	0.003	2.729	0.011
Urban population	-0.0828	0.0923	-0.897	0.377
Temperature	-0.0020	0.001	-2.503	0.018
GDP	-0.0219	0.0058	-3.789	0.001
Poverty	0.0008	0.000	1.674	0.105
Hospital Beds	-0.0167	0.0153	-1.095	0.283
Life expectancy	-0.0005	0.000	-2.182	0.038

4) CONCLUSION

This study presented a geospatial analysis of demographic, health, socio-economic, and climatic factors that influence the COVID-19 incidence in India. The study spans a 6-months timeframe that begins the day after the country proclaimed the unlock phase. Based on the available data, the findings of the current study support the hypothesis that climatic, demographic, health and socio-economic factors play a significant role in virus growth. Concerning climatic factors, a negative association was detected between coronavirus growth rate and temperature, whereas a positive association was found between coronavirus growth rate and humidity. Furthermore, an inverse association between COVID-19 growth rates was found with urban population and GDP per capita; in contrast, population density, percentage of older adults, and poverty percentage showed a positive association. Moreover, the health factors such as life expectancy and the availability of beds in hospitals have negative associations with the growth rate of coronavirus.

The GDP, percentage of the older population, average temperature, and life expectancy were considerably correlated with the coronavirus growth rate in India. Also, the interactions between the dependent variables affected the pandemic growth rate. The development rate was fundamentally affected by the interaction of the older populace and Gross domestic product, the old populace and populace thickness, and the Gross domestic product and old populace. Based on a comprehensive assessment of non-meteorological indicators, the policymakers can reform policies to keep in view the health protection and safety measures, demographics of the population, etc., across different states to prevent and mitigate coronavirus spread.

Declaration of Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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