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Predictive Modeling of Anthropomorphic Gamifying Blockchain-Enabled Transitional Healthcare System

Deepa Kumari*, B.S.A.S. Rajita, Medindrao Raja Sekhar, Ritika Garg and Subhrakanta Panda

Dept. of CSIS, BITS-PILANI, Hyderabad Campus, Hyderabad, Telangana, India

Abstract

The research objective is to explore more about anthropomorphic gamifying elements, mostly on how it can be implemented in a Blockchain-enabled transitional healthcare system in a more lucrative manner. Transitional healthcare services belong to that person who is suffering from lifelong conditions such as asthma, cancer, diabetes, and/or renal transplant. It is necessary to have organized systems, and on the same side, we need resources in place to assure that all needy experience a lucrative healthcare transition.

Anthropomorphic interfaces completely recognized as applying game elements or logistics into non-gaming contexts such as healthcare, by offering a fun and exciting environment. It is observed that there are very few games or web-based applications suitable to patients practically. Then, there is an interface with Blockchain architecture so that we can have health data security as well as motivation for staying healthy via reward mechanism (i.e., by tokenization of activities).

The conceptual framework is expected to come up with the integration of gamification, anthropomorphism, and Blockchain applications into the transitional healthcare system. Further, the output (reward points) from the organized system will help in predicting the health conditions of the patients.

***Keywords*:** Anthropomorphism, gamification, blockchain, transitional healthcare, predictive model, ethereum, smart contract

**Corresponding author*: p20190020@hyderabad.bits-pilani.ac.in

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18.1 Introduction

The overall provision of healthcare facilities helps in utilizing and achieving good health and is a sign of a developed country. Since independence, we achieved very little or limited progress in the healthcare facilities in India. Even though public health centers like hospitals and dispensaries are present, they are not capable to cater to the increasing demands of India's tremendous population day by day. In India, the main shortcoming of healthcare access depends on three factors such as supply, utility, and fulfillment. But, the presence of large gaps among these factors drives it to an unused system with unavailable facilities. So, there is an immense requirement for healthcare systems to be designed by integrating emerged technological innovations to whirl around new models for patient care. Hence, this chapter introduces to the readers a new level of understanding and practices that offer a distinct improvement in healthcare services by acquiring, integrating, analyzing, securing, and exchanging medical data at different levels of the healthcare system.

18.1.1 Transitional Healthcare Services and Their Challenges

Recently, transitional healthcare services have emerged to improve the quality and minimize the costs under the Affordable Care Act of 2010. Transitional healthcare, also called care transition [16], is defined as the systematization and continuousness of healthcare during the progress either from one healthcare setting to another or home. Care transition exists between healthcare specialists and healthcare facilities as their action and care demands change during the continuous period of incurable or acute illness.

In other words, transitional healthcare refers to the service which manages one's health condition, well-acquainted with appropriate knowledge to self-reliance, and then shifts them from hospital care to self-care [28]. This phenomenon belongs to that person who is suffering from some lifelong conditions such as asthma, cancer, diabetes, and/or renal transplants. Such prolonged treatment sometimes requires people to transit from one healthcare environment to another such as pediatric treatment to adult healthcare [42]. Thus, it may be burdensome for such people to sustain their engagement in the transition process. For example, an individual suffering from an acute disease at an early age initially needs clinical care, and as time passes, the treatment paradigm shifts to the family members.

In due course of time, this mostly gets shifted to self-care. Certainly, such a prolonged duration of treatment causes a negative impact on the psychological health of the individual and other members of the family. It may happen even due to various factors such as psychological changes, change in the healthcare personnel, and their expertise. Thus, there is a requirement for a targeted process that considers the physical and mental status of the individuals to deal with the transitional healthcare system.

18.2 Gamification in Transitional Healthcare: A New Model

Technology through gamified applications can play a vital role, particularly in transitional healthcare service, through the availability of favorable games for patient care, preferably to stimulate mental and physical health. Most of all, gamification is always proved to be a powerful tool that engages its users at a very high level [47]. Many developers and companies are now investing in gamified healthcare systems [40]. Gamification has been popular in non-game sectors such as business, health, institutions, and trade [49]. It positively inspires an individual to a healthy lifestyle through regular exercise and a healthy diet. Likewise, Fitbit, Jawbone UP, Nike Training Club, etc., use gadgets to keep track of the health activities and sleep score which links to online portals where the game players can track their activities and manage their lifestyle timely. It focuses on the improvement of the patient's engagement, motivation, and performance while executing a certain assigned work by incorporating simulator games, to achieve the goal in a more lucrative manner [45]. It utilizes game elements and dynamics to regulate the way of playing the game and to make routine activities more enjoyable and delightful. It also helps in promoting knowledge, learning, and behavioral aspects of self-management skills.

In game dynamic progression, we have certain game mechanics like achievements, levels, points, badges, trophies, and leaderboards. With the intense use of the internet and its applications, the mechanisms for delivering healthcare program help in encouraging people to record their daily activities in their blogs, uploading photos and videos on social media as well as participating in online surveys. There are three game dynamics: progression, feedback, and behavior. Thus, it is high time to add extra features like newly emerged Avatar concept into gamification to increase health, players' fun, and excitement.

18.2.1 Anthropomorphic Interface With Gamification

In some of the recent studies, it is evident that interfacing anthropomorphic with gamification gives a positive impact on the health of the players [41]. A human-like representation, similar to Avatar, designed with the human traits but is not human in actual, is called *Anthropomorphism*. Anthropomorphic interfaces are popular for applying game elements or logistics into non-gaming contexts such as healthcare or education, by offering a fun and exciting environment [2]. The avatar, human-like representation, is believed to have a positive impact and also provides a trustworthy interface to communicate with. Such mechanisms greatly motivate and encourage users to sustain their engagement. The usage of anthropomorphic agents fulfills dual purposes [7]. Firstly, we can converse (interact) with a virtual agent, and secondly, we can subtly increase the automation of tasks. The term "agent" usually refers to a software agent that performs a number of activities without any human intervention, i.e., highly independent. These agents are in different forms so as to develop the look and feel. They are 3D human representation, 3D non-human representation (with human-like characteristics), 2D human representation, and 2D cartoon-like non-human representation (with human-like characteristics).

There are certain advantages of implying an avatar in any research work. Firstly, it is much convenient for novice users to understand the functioning of the Avatar. Secondly, it is also helpful to grab the user's attention as it is found that people who interacted face to face can give more time on an online questionnaire survey and make fewer mistakes, unlike text questionnaires. Thirdly, it is also more efficient for us to speak questions rather than type them. Fourthly, we, the users do not have to go through painful codes and complex functions as these things are handled by the agent themselves. Somehow, it is evident that people with disabilities are using avatars as online characters while playing online games and the virtual world so as to preserve their anonymity [14]. This helps in overcoming the feelings of being different, social isolation, stigma, and can survive with long-term medical conditions. Certainly, we have already observed and analyzed that the use of gamification is now getting popularity by increasing the process of learning and routine-based healthy lifestyle. The addition of Blockchain for distributing reward points on the basis of routine-based health activities will be more attractive toward self-care.

18.2.2 Gamification in Blockchain

Blockchain is defined as a group of blocks that are connected by cryptographic links and contain distinct information in a secured decentralized manner [34]. Technically, it stores records in a tampered proof architecture. In 2008, Santoshi Nakamoto invented the Bitcoin protocol that remarked the revolution of shifting networking systems from centralized to decentralized systems worldwide. In fact, the achievements in this field have attracted the attention of academia, as the humanistic issues in health and social care are given more priority for further research in the Blockchain system and its ecosystem. After the advent of Bitcoin technology, Blockchain has influenced the interest of investigators to work on a generic technological platform by deploying different kinds of contracts [34].

Unlike Bitcoin, Ethereum has the additional functionality of smart contracts and, thus, helps in building and deploying decentralized applications. Smart contracts impose contractual agreement in the software and hardware so that the code that runs on Ethereum can control valuable digital assets or ETH [25]. It also performs transactions without the involvement of stakeholders and, thus, very complicated or expensive for the infringer involvement. Ethereum usually runs the smart contract codes after depositing transactional fees. Then, EVM executes smart contracts written in bytecode (solidity) on every node. After deployment, no one can alter the code which not only helps in decreasing transactional fees and also handles major risks in case of any faults. Ethereum works on some basic understanding of its underlying functionality and its interaction can be made by the use of Ethereum wallets, Mist as browsers, and Metamask as plugins. However, this platform has not gained wide acceptance among users and providers because of which it is difficult to predict the potential future applications.

The Blockchain ecosystem handles the humanistic and remunerative issues for the users, leading to unforeseen results in decentralized networks. It builds the bond of trust and integrity without any threat of security breaches. It is a recent trend to add features such as reward points to game apps and websites. Likewise, Metal Token [39], HoToKen[1], Sandblock[2], STORM[3], and POINToken[4] are systems to handle tokens and incentive on

[1] https://www.hotoken.io/

[2] https://medium.com/sandblock

[3] https://stormx.io/loyalty-program/

[4] https://medium.com/@point_token/the-point-token-systemgamification-and-achievements-for-the-Blockchain-bc368978e36

the Blockchain. These systems are capable to provide the benefits of the Blockchain such as security of data records, transparency, immutability, and transactions by the use of crypto tokens. This ledger will store Blockchain's assets (in the form of rewards and points) across multiple users.

Thus, the emergence of Blockchain leads to unprecedented heights for the potential of gamification when it comes to online engagement. It is therefore valuable to include gamification for healthcare issues in Blockchain technology. This integration helps in providing an incentive mechanism for earning reward points by the health player and also explores the performance of gamifying in a Blockchain system. In the coming years, Blockchain technology would be an indispensable environment for healthcare provisioning [1, 37]. Currently, we are lagging behind in the proper utilization of Blockchain technology as a gamified solution due to the lesser availability of cryptocurrencies and loyalty programs. Actually, it is a very tedious work to keep a patient engaged and motivated. The combined effort of gamification and Blockchain technology will make it possible to overcome the problem of patient engagement. The later section will explain the factors affecting the motivation of patients intrinsically or extrinsically.

18.2.3 Anthropomorphic Gamification in Blockchain: Motivational Factors

Anthropomorphic interfaces in the form of Avatars along with gamification helps a health player to increase the motivation or continue the engagement while interacting with the application [46]. Integration with Blockchain helps in the tokenization of healthcare activities for additional enjoyment and fun for the patients. According to the expert's views, a health player can develop a connection with his Avatar role when he foresees his real self in a virtual environment. It is expected that when people are motivated, their will power makes them follow their routine-based lifestyle or help them to change their behavior or habit at a point of need [43, 44]. So, we expect a similar transformation that may happen in the transitional healthcare people where their involvement toward their health can be improved [48]. To understand the effect of games on motivation [46, 47], we need to have a look at motivational theories.

There are several motivational theories that influence health player's behavior to encourage them for self-care. They are categorized as Maslow's hierarchy of needs, ARCS model of motivational design, and self-determination theory.

Maslow's hierarchy of needs theory [45] states that people's needs generally motivate them to perform actions. It is depicted by a hierarchical pyramid consisting of five levels. The physiological level is at the lower level and self-actualization is at the top level. Whenever the lower-level needs (called as deficiency needs) are satisfied before the top-level needs (called as growth needs), it may influence the behavior of the person. There are some intrinsic motivators (autonomy, mastery, and purpose), and they can be influenced by more or fewer satisfaction levels of Maslow's hierarchy of needs [45]. Basically, these intrinsic motivators aim to shape our lives (autonomy) by learning and creating new things (mastery) by taking care of ourselves (purpose).

In the ARCS (Attention, Relevance, Confidence, Satisfaction) motivational model [47], these four factors are utilized as a guideline for developing health player motivation through learning activities. It is important because patients should be well-acquainted with their health conditions so that they can take care of themselves. Overall, it acts as a problem-solving construct where we can recognize and work out those motivational problems associated with provided instructions. Firstly, Attention is defined to capture the interest of patients, stimulate a behavior of queries, and thus maintain the patient's attention. Secondly, Relevance signifies the process of achieving the patient's needs and also their positive attitude toward their goals. Thirdly, Confidence refers to build a positive expectation for achievement, build up patients' motivation in their competence, and acknowledge them about their real efforts and abilities to achieve success. Fourthly, Satisfaction defines by reinforcing achievement with reward points and also by providing valuable opportunities to patients to use their innovative knowledge or skills.

Self-Determination Theory (SDT) was given by Deci [48] and Ryan [49] where they discussed the challenges faced in lieu to the psychological need of being competent, valid, and autonomous and also to acquire the skill to master newly developed things. It is concerned with supporting the inherent potential of human behavior in simple healthy ways. This theory of motivation comprises intrinsic tendencies like Competence, Relatedness, and Autonomy. Competence can be described as the need to control the aftereffect and being a master. Relatedness refers to interaction, connection, and experience care for others. Autonomy specifies the art of being content and integrated with self. Motivation can be classified into extrinsic motivation and intrinsic motivation. In extrinsic motivation, patients carry out tasks or activities in favor of yielding rewards or benefits upon the execution of activities. But, in intrinsic motivation, patients are actually

enjoying while doing activities due to their deeper engagement and higher persistence.

18.3 Existing Related Work

As we are all aware of advancements in electronic health data, patient data protection regulations lead to the opening of new opportunities for the revolution of health data as well as easier for accessibility and shareability of patient health data. Besides this, serious issues of protection of sensitive health-related data can be solved using Blockchain technology that ensures data security and transactions and handles smooth integration with the healthcare organization. Many researchers have put forth their valuable research findings in the area of anthropomorphism, gamification, and Blockchain technology in the transitional healthcare system. We have presented related researchers work in the above areas in tabular format for exploring preliminary designs ideas quickly and efficiently.

Authors	Title of the Paper	Contribution
P. Zhang *et al.* [1]	*FHIRChain: Applying Blockchain to securely and scalably share clinical data*	They first discussed about the Office of the National Health Information Technology (ONC) requirements and then to override all those challenges by building a Blockchain-based decentralized app called FHIRChain (Fast Healthcare Interoperability Resources) for sharing medical data at remote scale.
Banks *et al.* [2]	*Emotion, anthropomorphism, realism, control: Validation of a merged metric for player–avatar interaction (PAX)*	They proposed a PAX (player-avatar interaction) system that works as a correlation between MMO player and game avatar and performs on psychological divergent perspectives. They focused on different psychological factors like paying sensibility and anthropomorphic use in autonomy.

Baranaowski *et al.* [3]	*Playing for Real. Video Games and Stories for Health-Related Behavior Change*	They demonstrated the positive impacts on health-related behavior by playing video games. They also considered the game elements and measures for employing them systematically into game outcomes.
Barata *et al.* [4]	*Improving student creativity with gamification and virtual worlds*	They focused on how student autonomy and creativity can be better improvised by combining Avatar into gamification. For this, they also presented a gamified course that performs in a virtual environment by the student and increases their grading performance.
Bartnect *et al.* [5]	*Measurement Instruments for the Anthropomorphism, Animacy, Likeability, Perceived Intelligence, and Perceived Safety of Robots*	They surveyed the computation of HRI by taking certain elements. They performed questionnaires and distilled their results on semantic different scales. This method helped them in analysing the requirement of standardized measurement tools for HRI.
Bickmore *et al.* [6]	*Taking the time to care: empowering low health literacy hospital patients with virtual nurse agents*	They illustrated on virtual nurse agent for educating and counselling hospital patients. These patients are mostly having low health literacy but by interacting with a virtual nurse, it is easier for them to follow directions in taking care of their health.

Birk *et al.* [7]	*Fostering Intrinsic Motivation through Avatar Identification in Digital Games*	They discussed the use of an avatar game for increasing the intrinsic motivation of the player. They performed an analysis on 126 participants for playing a customized game and identified that there is a sudden increment of autonomy, immersion, enjoyment, and thus a positive impact on their health and behavior, too.
Bogost *et al.* [8]	*Why Gamification is Bullshit*	They argued that gamification is good or bad for making it useful in our virtual environment. They considered that the use of gamification is nothing to do with the truth, it is just to impress or to conceal and in terms of this, they take out benefit from them.
Brewer *et al.* [9]	*Using Gamification to Motivate Children to Complete Empirical Studies in Lab Environments*	They implemented one solution toward the challenges encountered in small children while their mobile interaction (by touch or gesture interaction). They also conducted with young children and identified different challenges form empirical studies. They proposed validated techniques for the use of gamification to increase their engagement.

JH BrockMyer *et al.* [10]	*The development of the Game Engagement Questionnaire: A measure of engagement in video game-playing*	They discussed deep engagement while playing with video games and also considered that, presently, there are no measures to compute this subjective experience. For this analysis purpose, they surveyed by developing Game Engagement Questionnaire (GEQ).
CM Fox *et al.* [11]	*The development of the game Engagement Questionnaire: A measure of engagement in video game playing: Response to reviews*	They arrived with an argument that there are few tools to measure development in human attributes and fall short while calculating meaningful dimensions. For this, they also performed an analysis of ordinal level data and discussed the requirement of converting them into equal time intervals for both qualitative and quantitative data necessarily.
Akrolu *et al.* [12]	*Gamifying an ICT Course: Influences on Engagement and Academic Performance*	They demonstrated by implementing gamification for observing the effect of positive behavior like engagement and motivation in the field of education. They presented evidence by observing the association of commitment made by students in their studies.

Catrambone *et al.* [13]	*Quick Quiz: A Gamified Approach for Enhancing Learning*	They performed research on anthropomorphic agents and found that we can utilize an anthropomorphic agent to systematize the research. They discussed important key factors for the influence in the perception of agent-based interfaces.
Cheon *et al.* [14]	*Avatar: A Virtual Face for the Elderly*	They studied HCI interaction in the view of a user's interaction with avatars in a virtual environment and also discussed their behaviors with an aging population.
Dahl *et al.* [15]	*Measuring how game feel is influenced by the player avatar's acceleration and deceleration*	They also discussed about the game feel like sensation toward game control which is important for game designers understanding player's experience while playing games.
Daneman *et al.* [16]	*Moving on: transition of teen with type 1 diabetes to adult care*	They discussed the transfer from an early age to the adolescent medical care where they face certain difficulties in doing self-care within different environments. They also illustrated the purposeful, planned movement of the transition healthcare system for their physical and mental improvement.
Mull *et al.* [17]	*An exploratory study of using 3D avatars as online salespeople*	They examined the experiences of consumers while using 3D animated avatars despite salesperson. They surveyed 120 participants while interacting with a virtual salesperson in an online retailer

Seaborn *et al.* [18]	*Gamification in theory and action: A survey*	They described the gamification application in the field of the academy, business, information studies, education, HCI, and health. They discussed the standard guidelines required for the underdeveloped theoretical applications and academic experiences.
Barbieri *et al.* [19]	*Optimal predictive model selection*	They discussed the model selection based on accuracy and squared error loss so that it would give a better future prediction. They analyzed their model by Bayesian approach for their optimal results.
Laud PW *et al.* [20]	*Predictive model selection*	They described the problem of choosing the best model out of existing possible models. They described it in the view of predictive Bayesian to ignore the prior details of the given models and detailed interpretation of parameters in each model.
Tsung-Ting Kuo *et al.* [21]	*ModelChain: Decentralized privacy-preserving healthcare predictive modeling framework on private Blockchain networks*	They described a new framework named ModelChain in which they integrate Blockchain technology into their health model. They also described that the additional features of privacy maintaining the health data on the Ethereum network. They designed a new algorithm named as proof-of-information to evaluate online learning to increase interoperability between institutions.

Tsung-Ting Kuo *et al.* [22]	*Blockchain distributed ledger technologies for biomedical and healthcare applications*	They discussed Bitcoin and its underlying Blockchain technology. They also provided an overview of the latest Blockchain healthcare applications by focusing on improved record management and advanced medical research process.
R. Deng *et al.* [23]	*CrowdBC: A Blockchain-based Decentralized Framework for Crowdsourcing*	They developed Proof of Weak Hands (PoWH 3D) on the Ethereum platform where users buy tokens to deal with a charge of 10% commission fee and similarly for seller side. Usually, this fee would be distributed among the token holders based on the average rate. Similar to this, many new games developed such as PoWL, PoWD, and PoWC.
Slomiany SD *et al.* [24]	*Multi-stage multi-bet dice game, gaming device, and method*	They designed BetDice (a roll-a-dice game) where the decision of game players that is win or loss made by rolling a dice. Here is one advantage that the smart contract chooses any target number from 1 to 100 and, thus, ensures fairness to the player. It is one of the famous DApps because of working on the EOS chain; there is no need to go for a gas fee or time delay.

Kharif O [25]	CryptoKitties mania overwhelms Ethereum network's processing	He designed Cryptokitties that is a simulation game developed on the Ethereum platform where the different functions implemented on kitties. The record was made in 2017 by creating massive active users that lead to a great sensation and jammed the Ethereum network.
Lee J *et al.* [26]	*Is a Blockchain-Based Game a Game for Fun, or Is It a Tool for Speculation? An Empirical Analysis of Player Behavior in Crypokitties*	They discussed about Etheremon which is also simulated on Ethereum and also a better version of Pokémon in the view of playability. Other than this, monster types and skill systems are an extended feature in Etheremon so that game would become more interesting. As such, players can capture and train Etheremon so that they can fight to play with each other.
Min T *et al.* [27]	*Blockchain games: A survey*	They developed EOS Knights which is simulated on EOS platform and players in their chosen characters can be used to combat with the monsters in the game but if virtual player loses the game, then they have to deal with their earned items in game play. The strategy of playing game is like if there are more armaments furnished on the virtual player in the game play, then they will earn more rewards, and hence, they are more powerful in the play.

Gordon and Catalini [28]	*Blockchain technology for healthcare: Facilitating the transition to patient-driven interoperability*	They discussed the capability of the Blockchain healthcare system by giving digital access rights, patient privacy in the network, and data invariability and also by managing an excessive amount of health data.
Daisuke *et al.* [29]	*Tamper-resistant mobile health using Blockchain technology*	They performed an experimental analysis of registering health data to the Hyperledger fabric Blockchain platform and for this; they have taken medical records through smartphones.
Anuraag *et al.* [30]	*Implementing Blockchains for Efficient Health Care: Systematic Review*	They discussed the management of healthcare in the Blockchain. They have studied in managing the security and privacy of health records on the cloud system by the use of Blockchain. They have presented the potential benefits as well as limitations of Blockchain in healthcare without any practical implementation and evaluation of the system.
Rouhani *et al.* [31]	*MediChainTM: A Secure Decentralized Medical Data Asset Management System*	They derived an approach to point out the limitations of types of Blockchain and also discussed the utility of the Hyperledger Blockchain platform for the health data managing system.

Wu and Tsai [32]	*Toward Blockchains for health-care systems: Applying the bilinear pairing technology to ensure privacy protection and accuracy in data sharing*	They proposed two network security–based algorithms and also for distributed health data systems. They discussed developing rules and regulations for the healthcare system for security purposes.
Shen *et al.* [33]	*MedChain: Efficient Healthcare Data Sharing via Blockchain*	They designed a system named MedChain for incorporating health data into Blockchain technology through the P2P network. MedChain generates health data through medical services that can be accessed from different sources on the cloud system.
Khezr *et al.* [34]	*Blockchain technology in healthcare: A comprehensive review and directions for future research*	They studied different challenges while managing health data and their respective solution using Blockchain technology. They discussed the latest research going on distributed ledger technology by presenting different possible use cases revolving around Blockchain technology.
Litchfield *et al.* [35]	*A Review of Issues in Healthcare Information Management Systems and Blockchain Solutions*	They presented some challenges faced in the security and privacy of health data. They also discussed the solution to these issues through the use of Blockchain technology.

Vora *et al.* [36]	*BHEEM: A Blockchain-Based Framework for Securing Electronic Health Records*	They presented a Blockchain technology to secure EHR against breaching of patient details and health data. Their framework was analyzed to observe the performance in terms of the demands of a patient, healthcare professionals, and stakeholders.
Zhang *et al.* [37]	*Blockchain Technology Use Cases in Healthcare*	They presented different use cases of healthcare Blockchain. They have also illustrated on potential benefits of the Blockchain healthcare system by providing effective healthcare design.
Siyal *et al.* [38]	*Applications of Blockchain Technology in Medicine and Healthcare: Challenges and Future Perspectives*	They studied the importance of smart contracts for healthcare units by rationalizing the whole process. They discussed the sensitivity of health data and the potentiality of Blockchain in reducing the data loss and preventing data fabrication by the use of secured ledger technology.

18.4 The Framework

Here, we come up with a conceptual framework (refer Figure 18.1). This model consists of two modules. First module explains the working principle behind the anthropomorphic gamification interface with Blockchain technology where generation of tokens (rewards) for every health player takes place with the help of smart contracts based on Ethereum platform. The anthropomorphic interface with layers of gamification in the architecture of underlying decentralized applications is the Blockchain's proof-of-work (POW) implied on game elements. Second module explains the

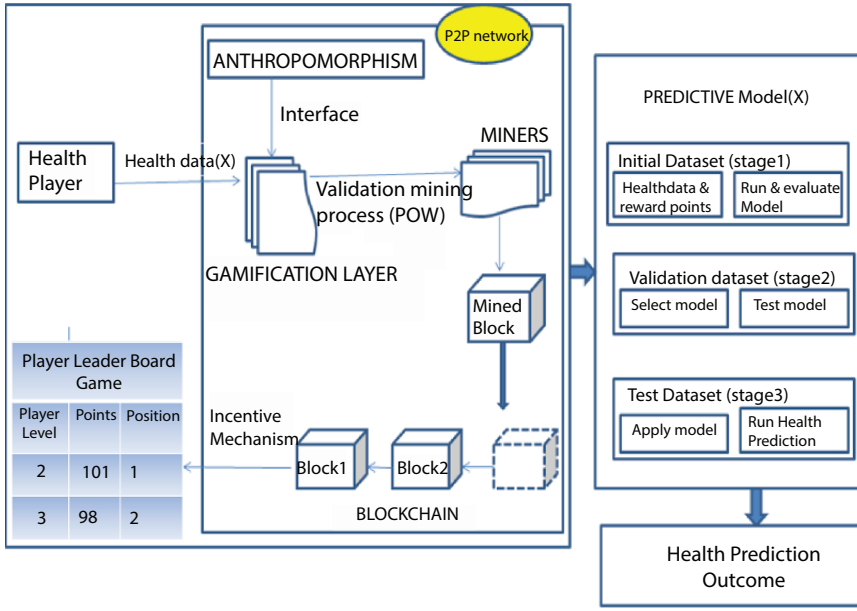

Figure 18.1 Framework of predictive modeling of anthropomorphic predictive modeling of anthropomorphic gamifying Blockchain-enabled transitional healthcare system.

predictive model for the health outcomes where reward points are taken as an input to evaluate it. By this framework, health players need not have to be familiar with the mind wrecking mining process as we are encapsulating the technical details to create a more appealing fun environment (Ganache GUI). With the help of this gamified mining, health players can earn reward points while doing health-related activities and compare them with other health players in the sense of competition among them. These reward points are going to decide the health of every player by the use of a predictive model, and thus, their focus on attaining better health can be achieved. Let us look at the functionalities of the components of the proposed framework.

18.4.1 Health Player

A health player is a patient with some chronic health issues. A sample size of 200 patients' health data was taken for the analysis of reward points and health prediction. We have taken those children and young people who suffered from some chronic diseases like, diabetes, asthma, cerebral palsy, and cancer.

18.4.2 Data Collection

The data comprises patient demographic details like age, weight, height, and also a record of daily activities like kilometer walked, heart rate, exercises, blood pressure, sleep score, and medicines intake. The age of the groups varied from the childhood stage, adulthood stage, and old-age stage.

18.4.3 Anthropomorphic Gamification Layers

The goal of anthropomorphic gamification is to make users aware of the implications of their healthy lifestyle, promoting them toward healthy behavior change, fostering resilience, and increasing motivation to fight diseases [6]. As we believe that in gamification, the popular technique using game progression rewards, trophies, badges, and points is not meant for engaging health players within communities as long as those rewards had no authentic assessment values [4]. Rather, it looks like an artificial form of achievement. Thus, there is a great requirement for adding authentic value (digital currency) to the points by using tokens. For this, we need to create an open standard where tokens are stored on the Blockchain so that a group of health players can easily store earned tokens in their Ethereum wallets. These tokens can be redeemed in the web store as payment for access to the health players which helps in creating a sustainable token economy and community. But, we know that medical data is always considered to be sensitive information and it needs to be protected from unapproved access. So, the main challenges of gamification in healthcare are patient privacy protection and medical data security. From all points of view, we propose Blockchain technology where we use smart contracts based on the Ethereum platform for creating unchangeable and safer utilization in the layer. Smart contracts are the building blocks of code that execute automatically applying the conditions of the agreement and commercial purpose like the game play in a secured fashion.

18.4.4 Ethereum

Ethereum is an open-source network and nowadays it is popular among active users for its Decentralization application (DApp) repository. The evolution of Blockchain technology always offers something new to our list of needs. This is possible due to consensus algorithms that make the Blockchain consensus sequence from each other. These algorithms are helping in making the majority group decision to include or

support a new individual to join in that particular group by the voting mechanism. Presently, the Ethereum platform makes use of POW consensus algorithm. POW is important for security which prevents fraud and enables trust. But, it requires all nodes to participate in the transaction for the validation of new nodes on the network. Also, there are certain issues with it like greater computation power is required, and pure decentralization is not achieved. Ideally, the decentralization application tends to recognize insertion anomalies, update anomalies, and missing attributes on the ledger records. It is done by the main elements of the smart contract that are written in Solidity. For the deployment of the smart contracts, we go for the Remix network (or Kovan network), and to deploy on testnet ethers, we need to pay with gas. Paying with gas is required to reduce the usage of computation power and also time to execute the transactions. Sometimes, malicious operators and complex contracts may lead to an infinite loop on the server-side. These payable transaction fees are usually decided by the willingness of the users for each unit of gas.

18.4.4.1 Ethereum-Based Smart Contracts for Healthcare

Smart contracts based on Ethereum platform was coined by "Nick Szabo" in 1993. It is a state machine and needs transactions to change the state through the mining process. It can do logical operations as well. In a general term, it is used for protecting information written in Solidity which is in a high-level programming language, and then, it is compiled into "bytecode", known as Ethereum Virtual Machine (EVM). Then, this contract is executed by all participating nodes by the use of their Ethereum Virtual Machines. Thus, every node holds a copy of the transaction along with its history on the peer-to-peer network. It also maintains the track of the current "state" so that every activity performed by the health player can be utilized to earn reward points. Hence, the EVM finishes the execution of a contract with its regulations that are introduced by the developer.

18.4.4.2 Installation of Ethereum Smart Contract

The following are the steps to install Private Blockchain Network:

1. First of all, we install NodeJS for providing javascript environment that is web3.
2. Then, we install Geth terminal where we write entire command in Go Language.

3. After that we install Git terminal window just like Linux.
4. Further, we install Ethereum Wallet (stores and manages Ethereum accounts and transactions) or Metamask wallet (an extension where to transfer and deposit ethers).

18.4.5 Reward Model

The reward model is used to buffer the reward points that are evaluated on the basis of daily healthcare activities. It works on the basis of the push-based flow method to distribute rewards to all the health players accordingly. This method computes rewards per hour spent in performing activities and operating on-chain computational overhead to a significant extent. It can handle more number of health players at a given instant t, where active health players are engaged in doing healthcare activities, let us say for doing exercises and taking medicines, create distribute events in a given timeline T. For every health player,

$$totalreward_j = sum_t reward_{jt} = activities_j * sum_t \frac{reward}{T_t}$$

that is, total reward for every health patient is calculated on the basis of their routine-based healthcare activities in given timeline order and these rewards are stored in a table in chronological order which is further used in the predictive model.

18.4.6 Predictive Models

There exist many efficient and affordable predictive models because of the increase in the running capacity of thousands of models on multiple cores. What matters is the suitability of the predictive model for a given input dataset. So, it totally depends on the desirable nature of the predictive target. We have taken different machine learning algorithms to design a model. They are linear regression, logistic regression, support vector machine (SVM), artificial neural networks, etc.; the different machine algorithms work on different nature of data. Linear regression is used when we want to predict continuous values. Logistic regression is considered to be a more powerful statistical way of modeling a binomial result with one or more descriptive variables. It estimates the relationship between the categorical dependent variable by the use of the logistic function. Next is the SVM that can be used for binary classification and also for multi-class

classification indirectly. It can be used for both linear and non-linear decision boundaries. The last one is an artificial neural network that can be used for multi-class classification and non-linear decision boundaries. The implementation of our chosen model depends on the best accuracy provider for the prediction of the health of the patients.

18.5 Implementation

This section gives a clear picture of our research tasks and of the processes through which our conceptual framework validates the goal of our research work. It explains the purpose of our research and the methodology behind it and, finally, assesses the reliability of our findings in the result analysis section.

18.5.1 Methodology

Initially, a health player with his avatar role participates in the game app and gives challenges by doing healthcare activities and then updates the records by the use of a tracker. The health player is initially given variable tokens. Then, the smart contracts based on the Ethereum platform compute rewards points (token) by the application of logical operations. Every activity performed results in the creation of tokens that is regarded as reward points. These reward points are computed based on the aforementioned formula in the reward model (refer Section 18.4.5). Those health players who are sincerely participate in the game play and perform every activity thoroughly gather the maximum reward points. These stored reward points of respective health players are further used for the analysis of health predictions.

Generally, predictive model comprised of different stages that include preparation of data, quality of data, reduction, simulation, prediction, and result analysis. At the first stage, we apply Principal component analysis (PCA) technique on our dataset. PCA method is an unsupervised machine learning algorithm which is used to reduce the number of features describing our dataset. Apart from this, the PCA method reduces the dimensionality with the motive of retaining information as much as possible. Next, at the second stage, we perform the transformation, center, and scaling feature on the test set as well. We compare logistic regression and SVM models based on their better accuracy. Thereafter, in the third stage, we select the appropriate ML model with the best accuracy for the health prediction of the patients.

18.5.2 Result Analysis

Before we begin with our health dataset, firstly, we need to think about the environment to deploy our smart contracts. We would like to use a local Blockchain that runs on our machine, requires no internet access, and most importantly provides all the Ethers that we need and mines block instantly. Hence, we have opted for Ganache as a local Blockchain. Here, we can see a list of accounts with their respective address, Ether balance, and other relative information (refer Figure 18.2). Accounts with their addresses are actually used for interacting with this Blockchain, and also, we have the list of transactions done in the local network (refer Figure 18.3).

We can have a visualization of the transaction in the Ganache GUI. Then, Web3JS is used to send the data block to the chain after the validation of the transaction is done. The stored reward table is then used by a predictive model. PCA (refer Figure 18.4) is used for feature reduction by extracting the important ones from a large pool. We have graphically represented a heat map of the correlation of features. Figure 18.5 shows the performance of different ML algorithms like logistic regression and SVM.

The performance of the logistic and SVM models is evaluated based on four factors: F1-score, recall, precision, and accuracy that are represented in the below figure (refer Figures 18.5A and B). F1-score is even more suitable for imbalanced class distribution and is more preferable than accuracy to evaluate the models. Next is precision which tells about the relevant output and recall shows whether the output is correctly classified. Thus,

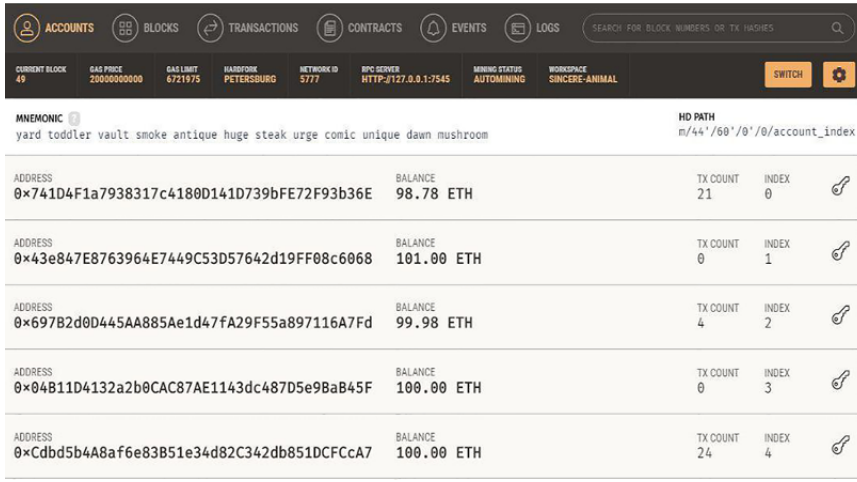

Figure 18.2 Accounts used in making transaction.

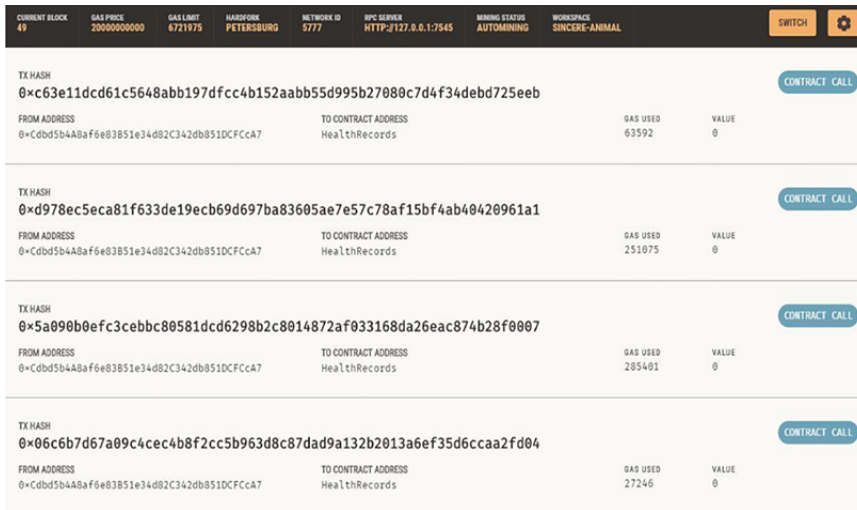

Figure 18.3 List of transactions on the network.

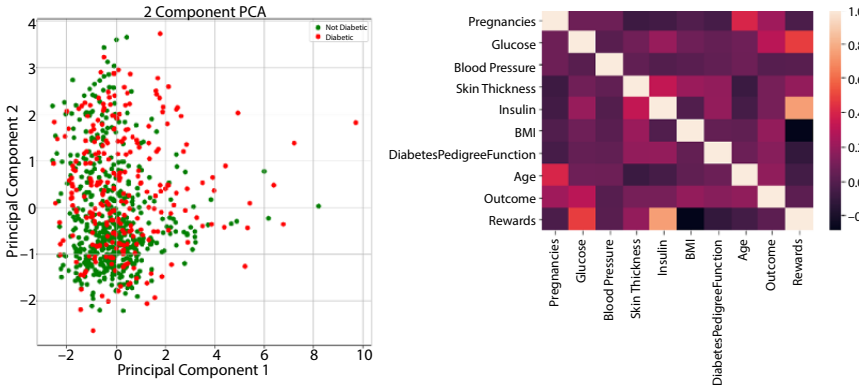

Figure 18.4 Principal component analysis on diabetes patient data and heat map of correlation of features of diabetes patient with their respective earned reward datasets.

logistic regression performs better than SVM in terms of four factors (refer Figures 18.5A and B).

The ROC curve (refer Figure 18.5C) for logistic regression helps in determining the best cutoff value for predicting whether a new observation is a "failure" or a success. As given in the figure, an AUC of 0.83 suggests excellent ability to predict patient health status. Logistic regression is considered to be better because of its 79% accuracy which is quite considerable

Figure 18.5A. Logistic Regression

	Precision	Recall	F1-Score	Support
0	0.82	0.90	0.86	107
1	0.70	0.55	0.62	47
Accuracy			0.79	154
Macro Avg.	0.76	0.73	0.74	154
Weighted Avg.	0.78	0.79	0.78	154

Figure 18.5B. Support Vector Machine

	Precision	Recall	F1-Score	Support
0	0.77	0.94	0.85	107
1	0.73	0.34	0.46	47
Accuracy			0.76	154
Macro Avg.	0.75	0.64	0.65	154
Weighted Avg.	0.75	0.76	0.73	154

Figure 18.5C. ROC Curve in Logistic Regression

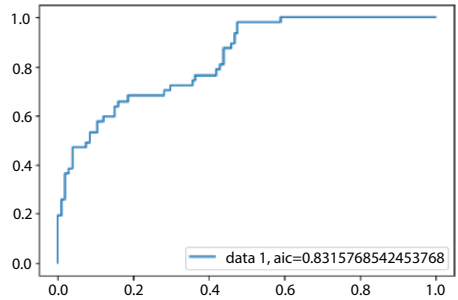

Figure 18.5 Different ML algorithms' output for computing best predictive model. (A) Logistic regression. (B) Support vector machine. (C) ROC curve in logistic regression.

for our proposed model. It can be concluded that the logistic regression model is better suited for the prediction of the health status of the patient.

18.5.3 Threats to the Validity

Just as every coin has two sides; the proposed framework has also its limitations. One of the major issues with Ethereum is scalability; each smart contract and transaction has to regulate every node to be processed in the network before being validated. In terms of speed also, Ethereum limits 15 transactions per second and 1 million transactions per day as its full capacity, which clearly shows its limit.

Because of the scalability issue in Ethereum, researchers are working on EOS which can scale to millions of transactions per second. This would make it possible to raise the bar in handling the real-world application. Thus, EOS can help to revolutionize the healthcare industry into the most scalable Blockchain network.

18.6 Conclusion

This chapter introduced the fundamental of anthropomorphism that can be interfaced with gamification for better help to transitional healthcare patients. An implementation of the Ethereum Blockchain gamification with incentive mechanism is shown that engages and motivates health players to take care of their health in a lucrative manner. We have shown experimental results of the transaction of nodes while computing rewards to healthcare players. Further, we have shown the performance of selective predictive models in the prediction of the health outcome of any patient.

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