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# AUTOMATICMEDICALDISPATCHERWITHD YNAMICTELE-MONITORINGSYSTEM

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**Abstract;Recentadvancementsininformationtechnologyhaveimprovedthedesignanddevelopmentofdiseasepredictionsystems significantly.Thediseasepredictionsystem is useful in diagnosing diseases by analyzing medicaldata.Inthisdigitalworld,diseasepredictionsystemsareextremely important, especially duringpandemic situationswhen physicians are in high demand andpeople are unable toreachhospitalstomonitoranddiagnosetheirhealthconditions. Manymedicalexpertsystemsanddiseaseprediction systems have been published in recent years. Still,thereisagapforpeopletohaveaneffectivediseaseprediction system to predict a patient's disease and severitylevel at the right time. Predicting the impact level of disease inthe human body is considered one of the most difficult issuesnowadaysdueto theincreaseinvoluminousmedicaldatawithvariousnewsymptoms.**

## 1. INTRODUCTION

### *1.1 HEALTHCAREMANAGEMENT*

Nowadays people are exposed to many health issues due totheirsedentarylifestyles.Healthcaremanagementisanimportant task today due to the rapid growth of diseases andthe advent of new symptoms of the old diseases. People arenotgettingmedicalattentionontimeduetoinefficientmedical facilities and most healthcare organizations cannotmeet the medical demand of the public. Prediction of diseaseis also another important issue with healthcare managementdue to the formation of unusual symptoms which is aboutvarious diseases. An effective healthcare system is needed toprovidebetterdiseasepredictionandtreatmentwithminimized costs. Due to the advent of unusual symptoms andan increase in the voluminous data of patients with variousdiseases, predicting the impact level of disease in the patient'sbody is considered one of the most difficult issues nowadays.Recent advancement in information technology has changedthewayhealthcaremanagementiscarriedoutanddocumented.

The World Health Organization (WHO) has identified thatheart, diabetic and cancer diseases are deadly causing morethan 12 million causalities in the world. Comparatively, thisnumberishighinallcountries,especiallyindevelopingcountries.Accordingtoastatistic,thereisacausalityhappening every 30 seconds due to any one of the above-mentioned diseases. Diagnosing these diseases is necessarytoday and it is also a challenging task for the healthcaredepartment of each nation. Diagnosing the disease is vitalbecause patients are not aware of the symptoms which fail tomonitorthediseaselevels andhealthconditions

#### *1.1.1 IoTinHealthcare*

The Internet of Things (IoT) is a network of physical objectssuchasdesktops,Laptops,SmartphonesTablets,etc.TheseObjectsareembeddedwithsensors,software,andothertechnologiestocommunicateandexchangedatawithotherdevices and systems over the internet. Remote monitoring anddisease prediction in the healthcare sector is now possible withIoT-enabled devices, which can keep patients safe and securewhile also inspiring physicians to provide superior treatment. Inhealthcare IoT devices are rapidly integrated withAI and MLinto disease prediction systems and process the medical data forefficient diagnosis of diseases. Furthermore, IoT-enabled diseaseprediction and remote monitoring of patients have a huge effecton reducing consultation time, minimizing healthcare costs, andimprovingdiseasepredictionaccuracy

IoT undeniably changes the healthcare industry by redefining thespaceofdevicesandhumaninvolvementinthedeliveryofhealthcare solutions. The following are some of the main benefitsofIoTinhealthcare:

- Improved Treatment: It allows doctors to make evidence-based,well-informeddecisionswhileprovidingcompleteaccountability.
- CostSavings:IoTallowsforreal-timepatienttracking,reducing the number of unnecessary doctor visits, hospital stays,andreadmissions.
- Rapidly Diagnosis: Using continuous patient monitoring andreal-time data, doctors can diagnose diseases at an early stage,evenbeforemajorsymptomsoccur.
- Preventive Medical Care: Continuous health monitoring allowsfortheprovisionofproactivemedicaltreatment.
- Drug and Medical Equipment Management: In the healthcaresector,handlingmedicationsandmedicalequipmentisabig challenge.Theseareefficientlyhandledandutilizedbyconnecteddevices,resultinginlowercosts.

Data created by IoT devices not only aids in efficient decision-making but also ensures that healthcare operations run smoothlywithfewersystemcosts.IoTdeviceusessensordata, whichhelps medicalpractitioners understand sensitive circumstancesmore quickly and effectively also patients can be better informedabouttheirsymptomsandprogress.Pulse-oximeters,electrocardiograms,thermometers,fluidlevelsensors,and Sphygmomanometers (Blood pressure), etc. are examples of IoTin healthcare sensors that are beneficial for analyzing the currentpatientcondition

### *1.2 NON-COMMUNICABLEDISEASES*(NCDs)

The diseases which are not communicable directly from onepersontotheotherpersonarecallednon-communicablediseases.NCDs are connected with the way aperson or groupof people survives called a lifestyle disease. WHO recognizednon-communicable diseases including heart, diabetes, cancer,chroniclung,andstroke(WHOReport,2018).Accordingto the WHO non-communicable disease profile released intheyear 2018, non-communicable diseases causes nearly 70%of death around the world, among them 82% i. e. 16 millionindividualsprematurelydeceasedbeforetheageof70years. These NCDs are generally caused by four major riskfactorsimproperandunhealthydiet,lackofphysicalactivities,abnormalweight,smoking,tobaccousage,alcohol abuse, stress, age, family medical history, heritage,andpersonalcircumstances.

### *1.2.1 HeartDisease*

Heartdiseasedenotesanyconditionwhichaffectsthefunctionalities of the heart. Heart disease is categorized bydifferent causes such as Coronary artery and vascular disease,Heartrhythmdisorders(arrhythmias),Structuralheartdisease, and heart failure. Among them, coronary artery andvascular disease will happen when the arteries of a heart areblocked.This is a common heart disease and causes chestpain (angina). In addition, vascular disease is a problem withbloodvesselsthataffectbloodcirculationandheartfunctionality.Heartrhythmdisorders(arrhythmias)occurbecause of less heartbeat which affects the blood circulation.Structural heart disease refers to abnormalities of the heart'sfunctionalities including its valves, walls, muscles, or bloodvesselsneartheheart.

The WHO predicted that heart disease is a deadly disease andalso identifiedthe deathrate inthe world asaround 120lakhs. The number of death cases of heart disease is high inall countries, particularly in developing countries includingIndia,SriLanka,Nepal,Pakistan,etc.Now,thislife-threateningdisease affects the adult withmaximumdeathrateandincreasedthe unpredictedfatality throughouttheworld. An analysis expressed that one person meets a heartdisease deathevery 40 seconds in the United States (Bengioet al. 2013). Heart failure will happendue to high BloodPressure (BP) and other serious symptoms which is the laststage of the disease leading to fatal. The major symptoms ofheart disease are including high BP, high cholesterol, chestpain, and Sleepapnea.Heart diseasesare dragonized andcategorizedbasedonindividuallifestyle,familymedicalhistory,and medical health reports.Medical health reportsare evaluated with the following reports Electrocardiogram(ECG),cardiaccatheterization,cardiacComputerizedTomography(CT)scan,cardiacMagneticResonanceImaging(MRI),stress test,andHoltermonitoring.

### *1.2.2 DiabetesDisease*

Diabetesmellitusiscommonlyreferredtoasdiabetes.Diabetesisametabolicdiseasethatcauseshighbloodglucose. The insulin hormone supplies sugar to body cellsfrom the blood whichgives energy to humans. Whenthecells do not make enough insulin the person is identified asdiabetic. If diabetes with high blood sugar is untreated, it willdamage the nervous system, eyes, kidneys, and other organs.Generally,diabetesisclassifiedintothefollowingtypesprediabetes, gestational diabetes, type 1 diabetes, and type 2diabetes. Among them, Type-2 diabetes is more severe thanType-1 diabetic disease. Autoimmune disease is said to betype 1 diabetes, which affects pancreas cells where insulin isgenerated. When the human body becomes insulin resistantand sugar builds up in the blood indicates type 2diabetes.During pregnancy, the blood sugar level is increased whichindicatesgestationaldiabetes.Prediabetesisaconditionidentified withhighbloodsugarabovethenormallevel. AccordingtotheWorldHealthOrganizationreport,around fourtimesof people were affectedby diabeticsbetween1980and2014.Inthesestatistics,thenumberofadult patientsincreased from 4.7% to 8.5%. Specifically, the 5% of patients areincreased in the last one and half decades and it also increasingrapidlyinhigh-incomecountries.Moreover,itcausesmajorissuesincludingheartattack,stroke,blindness,andkidneyfailure.Due to this reason, the death rate of diabetes is 16 lakhsin 2016. In addition, 22 lakh people lost their lives in 2012 due tohighbloodglucosethatoccursbeforetheageof70(WHOReport, 2021). Common diabetes symptoms include increasedthirst and hunger, weight loss, blurry vision, frequent urination,andfatigue.Diabetesisassociatedwithmajorcomplications suchasheartdisease,nephropathy,retinopathy,hearingandvision loss, skin infections, depression, dementia, etc. Diabetescan be diagnosed by doctors with the help of blood tests whichincludes fasting plasma glucose measures and hemoglobin A1Ctest.

## 2. RELATEDWORK

A literature review in the context of a disease prediction systemhelpsidentifytheissues,complexities,andimportanceofexistingworks.Also,itsupportsidentifyingsuitablemethodologies,tools,anddatasets.Thischapterprovidesanexhaustive review of various research works already done in thedirection of healthcare management, disease prediction system,data mining, machine learning, deep learning, feature selection,andclassification.

### *2.1 REVIEWOFHEALTHCAREMANAGEMENT*

Nazar etal. (2020) conducted an investigation and discoveredthat diabetes, hypertension, and cholesterol levels have a clearrelationshipwithCOVID-19severity.Furthermore,theydiscoveredthevirusisstronglylinkedto otherdissociativedisorderssuchascancer,stroke,andkidney-relateddiseases.Finally,researchersadvisedextremecautionforCOVID-19patients, whose reports have been linked to cancer, stroke, andkidney disease. They have also identified several risk factors forpoor COVID-19 outcomes, such as patients being elderly, havingasmokinghistory,orhavinganyotherclinicalcondition.Moreover,theysuggestedtreatmentoptionsbeinvestigatedfurther to provide optimal care and ensure better outcomes forpatients suffering from these comorbidities. Camilla et al. (2020)declared a few suggestions to handle the current issues in thehealthcare domain. The main aim of this work is to facilitate thelearning strategy while introducing healthcare applications. Thisanalysis applied a qualitative method by conducting reviews andpointingoutthenecessity.Phoutsathaphoneetal.(2020)conductedasystematicreviewforsynthesizingthevarioushealthcare articles and identified the guidelines on the diabeteshealthcare system which increases the competency Abbas et al.(2019)conductedareviewof202publishedarticlesandidentified85 high-rankedarticlesthatarerelevanttothedecision-making process on healthcare datasets. These articleswere categorized into 9 major applications including healthcaretechnology,medicalequipmentmanagement,andhealthcareservices. Moreover, in this survey, the ranking has been done bythecategorizationofvariousaspectsincludingthedecision-makingandapplicationareas.Thevarioushealthcareapplications applied many decision-making approaches that areevaluatedandrankedaccordingtotheservicequalityofhealthcare and medical service applications. Waleed et al. (2019)suggested some guidelines to manage the diseases and handle themedical professionals through the heart failure expert committeewhich is comprised of thirteen specialists who are chosen frombothprivateandpublicsectors.Thecommitteefinalizedthe guidelines and disputes for managing critical situations in thedisease diagnosis process in Saudi Arabia. Chun-Song et al.(2017)developedmanymethodstopreventheartdiseaseespecially cardiovascular he also improves the healthcare fornon-communicable diseases. Gorunescu (2015) conducted anextensivesurveyabouthealthcaremanagementusingMachine LearningtechniqueswhichincludetheSVM,GeneticAlgorithm(GA),NeuralNetworks,andnearestneighbor. These are applied for the diagnosis of the deadliestdiseases likeheart,cancer, anddiabetesdiseases.

*2.2 REVIEW*OF DISEASEPREDICTIONSYSTEMDebarpitaetal.(2020)designedaframeworkthatadoptsaroughsetawarelatticetorepresenttheknowledgeinamedicalexpertsystemthatisovercomingtheissueofredundancyandinconsistency.Theirframeworkprovidesaflexiblemethodtoexpressthediversepossibilitiesamongthediseasesymptoms.Mantimetal.(2020)proposedthreemethodsthatareappliedforimplementingDr.Flynxz’sAilmentPredictionandallergy managementapproaches.Theexperimentalresultsrepresenttheperformanceenhancementintermsofpredictionaccuracy.Thesystemhasbeenusedtopredictdiseasesbyusingthefuzzyinferencesystemwhichapplies theMamdani-Sugenotype.

Oyelade et al. (2018) developed an input generation modelwhichaddressesthedrawbacksviathe inferencecreationprocess,thelexiconofbreastcancerdisease,rules,andnatural language processing. Their method feeds the input tothe inference engine that has rules and ontology. Finally, theypreparedalistoftokensandusedthemintheexpertsystemtodiagnosebreastcancer.Theirexpertsystemachievedbetterpredictionandalsogeneratesadditionalinputdata.SiqiQiuetal.(2018)describedtheIF…THENrulesforrepresenting the data incompleteness,vagueness, and non-linear casual relationships by assigning the degrees to all thepossiblevaluesoftheuniverseconsequentlywithtimeinterval-based weights. They have proposed an evaluation-basedsystemtoperformmodelingandriskassessmentprocesseswithextendedrules.Finally,theyhaveappliedtheir system to predict the possibilities of two different usecases.

Ramiro et al. (2017) developed a fuzzy logic incorporated amedical expert system to assist physicians in the process ofpredictingnephropathycontrolwithtype-2diabetes.Thisexpert system was designed using the practical guidelines andtheknowledgeprovidedbyexperiencedmedicaldoctors.Moreover, this system considers the blood glucose level, uricacid, age, serum creatinine, dyslipidemia, and hypertensionfor prediction. After being experimented with many times,they achieved more than 93% prediction accuracy and also,they proceeded the treatment successfully and cured them.Even though, they have failed to estimate the failure stages ofpatients.

Gwo-Haur et al. (2006) developed a time scale-based methodforcollectingmedicaldatafromexperiencedphysicians.Theirmethodconsumedconsiderabletime,basedontheconsidered disease symptoms in various periods. Finally, theyhave proved that their expert systems have achieved greaterperformancethantheconventionalknowledgeacquisition approach. Lenka et al. (2001) explained the various medicalexpertsystemsthatapplyintelligentrules.Thevariousdatasetssuchasdiabetes,cancer,andheartdiseasesareappliedforevaluatingthedifferentexpertsystemsandachievingbetterprediction accuracy.Theyhaveconsidered theimprovedmethodologiesand effectivestepsto diagnosethediseases.

*2.3* **REVIEWOF DATAMINING**

Abbas et al. (2020) conducted an experimental study on thereal medical dataset that was collected from 136 cancerouspatients by using the data mining algorithms including Multi-layerPerceptron(MLP),ANN,SVM,Classification&Regression Tree (CRT), Logistic regression and C 5.0. Thedatasetcontainsdetailsincludingsmokinghistory,hypertensiondetails,andbloodpressureatthetimeofadmissionfortheagedpeople.Thealgorithmsachievedbetter classification accuracy. Heudel et al. (2019) developedanew dataanalyticsmodelby incorporating dataminingalgorithms along with Natural language Processing (NLP) tocategorize the data effectively. This model achieves betterresults andreachedthe performancelimits.Heudeletal.(2019) analyzed the prognostic factors over elder women'streatment records as advanced treatment by applying the dataminingalgorithms.

Dominic et al.(2015) investigated the disease severity ofchronic diseases by applying the IC9 diagnostic codes. Foridentifyingthediseaseseverity,variousdataminingalgorithms are applied and gathered the heart and diabetesdiseasetypes.Thesystemanalyzesandidentifiestherelationship between the human anatomic methods such ascirculatory, nervous, renal, musculoskeletal, neoplasm, andrepository systems that are all identified as human anatomicmethods. The disease severity level has been identified byusing human anatomic methods. Baiju et al. (2015) applieddata mining techniques to analyze the clinical data includingdiabetes research with the standard epidemiology and healthservices. Even though, the issues are necessary to be resolvedbyapplyingtheminingtechniquestomedicalresearch.Jesmin et al. (2013) investigated the health factors of heartdiseaseinhumanbeings.ThisworkappliesARMandintelligence techniques for identifying the factors from theUniversityofCaliforniaIrvine(UCI)machinelearningrepository dataset that is utilized to make decisions on patienthealthrecords.

Gloria et al. (2008) aimed to evaluate the health resourceutilization in particular lung cancer-affected people. The datamining algorithms were applied with the propensity score forvarying predictive capability. The analysis shows the use ofdata mining techniques to handle complex and huge volumesof publicly used lung cancer data. End of the analysis, it isdemonstrated that the model combines the Decision Tree andArtificial Neural Networks which provides better predictionaccuracy.

*2.4 REVIEWOFMACHINELEARNING*

Joshiet al.(2020) conducted anextensive review of the MLapplications that are available for diagnosing various diseases.The review explained the different kinds of medical diagnosissystems that use ML algorithms forperforming classification.Themajorobjectiveofthereviewistosupplydetailedinformation about the role of ML and AI in disease diagnosis.Finally, this review provides a lot of information to the practicingphysician and also assists to evaluate the ML algorithms in theprocess of disease diagnosis through the prediction result on thedisease dataset.Saurabhet al.(2020)conducted anextensiveanalysis of the machine-learning approach along with the datasetssuch as D1 and D2. Among them, D1 considers conjunctivitis,diarrhea, stomach pain, cough, and nausea-related data and D2containsthestandarddatasetcalledWebKB4.ThemachinelearningalgorithmsnamelytheRadialfunctionincorporatedSVM,MLP,andtheRandomForest(RF).Finally,theyachieved

97% as the highestaccuracy intheir experimental results.Moreover, they also showed the memorization process andtesteditinthedirectionofmaintainingstabilityandreliability. Sabrinaetal.(2019)appliedmanymachinelearning algorithms with the adaptation of non-linear supportvector curves on the Radial Basis Function (RBF) algorithmalongwithanoptimizedGridsearchmethodandobtains more than 95% accuracy on heart disease dataset that is a setof records collected in more than two years. Mahdieh et al.(2018)describedthedifferentMLmethodswhichareavailable with advanced techniques like data analytics anddeep learning on IoT. In addition, the characteristics of IoTdata are also applied to find the different approaches such asIoTwithdataanalyticsanddatastreaminganalytics.Inaddition, deep learning along with data analytics is capable ofachieving reasonable accuracy on medical datasets. Kohli&Arora(2018)appliedvariousclassifierstoclassifythedata setssuchascancer,diabetes,andheartdiseases.Afeatureselection methodwasincorporatedasabackwardmodel by applying the value test. The experimental resultsexpressed the strength of the ML on various medical datasets.Enas (2018) investigated thewidely appliedML algorithmsto predict various life threaten diseases such as heart diseaseand cancer diseases. The ANN, k-NN, DT, and ARM wereapplied for performing the classification process and analyzetheresults.Thisalgorithmhasachievedapredictionratebe tween 70% - 100% accuracy and still, it is not sufficient forthecurrentworld.

## 3. METHODOLOGY

### *3.1 INTRODUCTION*

The use of disease prediction systems in hospitals and otherhealthcare facilities has increased dramatically and portabledisease predictionsystems basedonnew technologies arenow a major concern for many countries around the world.IoT has aided the advancement of healthcare from face-to-face consultations to telemedicine, it has a huge effect onreducing consultation time, minimizing healthcare costs, andimproving disease prediction accuracy. In IoT-based diseaseprediction systems sensor data can help medical practitionerstounderstandsensitivecircumstancesmorequickly andeffectively, also patients can be better informed about theirsymptoms and progress. In healthcare IoT devices are rapidlyintegrated with AI and ML into disease prediction systemsandprocessthemedicaldataforefficientdiagnosisofdise ases.

Thecurrentresearchscenariohaslimitationsoverhighdimension alandcomplexdatasetsofdiseasepredictionsystems.Tofulfilling theresearchgap,anoveldiseasepredictionsystemisproposedinw hichnovelfeatureselection algorithms and deep learning models are used topredict heart,diabetes,andcancerdiseases.Here,featureselection algorithms are used to identify the optimal featuresthat are helpful for the classifiers to make abetter decisionwithreducedcomputationtime.Moreover,deeplearning models are used to predict diseases more accurately than theother existing methodologies. The research framework whichcovers architecture, workflow, and performance evaluationmetrics isframedinthis chapterindetail

### *3.2 PROPOSED DISEASE PREDICTION SYSTEMARCHITECTURE*

The architecture of the proposed disease prediction systemcomprisesfiveimportantmodulesnamelyuserinterface, medicaldatabase,featureselection,classification,and diseasepredictionmodulesasshowninFigure3.2.

#### *3.2.1 UserInterfaceModule*

The user interface module serves as a bridge betweenthe userand the disease prediction system. It collects patient data usingIoTdeviceslikedesktops,laptops,smartphones,andtablets,alon gwithnecessarysensorslikepulse-oximeters,electrocardiograms,thermometers,fluidlevelsensors,sm artwatches, and Sphygmomanometers, and converts the userrequest into query format. The user query contains the patientdetails such as name, age, gender, contact information, sensordata, symptoms of diseases, and medical reports. To process thereal-timestreamingfeatures,itemploystheslidingwindowprotocol.Witht hehelpoftheuserinterfacemodule,theformatted user's query or request is to be forwarded to the diseasepredictionmodule.Anadditionalimportanttaskoftheuserinte rfacemoduleistocollectclassificationresultsfromthediseasepredicti onmoduleandsendsthemtotheusersasadiseasepredictionreport.

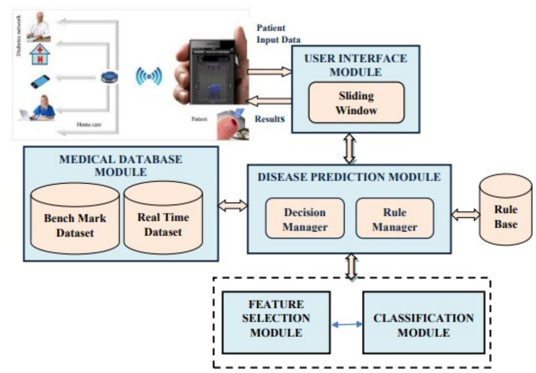


**Figure3.1 ArchitectureofProposedDiseasePredictionSystem**

##### *3.2.1.1 Slidingwindow*

A sliding window is used to process continuous queries over datastreams. When data elements arrive in a continuous stream, asliding window answers the queries for the most recently arrivedN elements. The proposed work handles the streaming featuresusing a self-adapting sliding window protocol which is used tohandletheoverflowofstreamingdata.Itadjuststheslidingwindow size according to the streaming feature arrival rate usingsliding window threshold parameters. The features arrival rate isfrequently calculated by the self-adapting protocol and updatesthe corresponding threshold values to change the window size(Dianlongetal.2019).TheSlidingWindowSize(SWS)iscalculat edusingEquation(3.1)

The sliding window selects the optimal features from streamingdata in real-time using a heuristic function. The heuristic functionprovides information to search about the direction of an objectivefunctionusedinthefeatureselectionprocess.Itoffersamathe matical method for selecting relevant features from a datastream. It calculates the distance betweencurrent and optimalfeatures and assigns heuristic values to streaming features basedonfeatureinformationobtainedfromthefeatureselectionmodul e. The sliding window collects streaming data from IoTdevicesandsendsittothediseasepredictionmodule.Thedisease prediction module examines the required streaming dataslidingwindow

#### *3.2.2 MedicalDatabaseModule*

Themedicaldatabasemoduleincludesstandardbenchmarkdatasets as wellas real-time streaming datasets. The standardbenchmarkdatasetsareheart,diabetic,andcancerdiseasedat asetsfromtheUCIMachineLearningRepository.Real-time streamingdatasetsincludedatasuchaspatientdetails,symptoms, and medical reports collected from patients viaIoTdevices.Furthermore,hospitaldataiscollectedandstored in real-time streaming datasets. All of these datasetshave varying numbers of records, and each record in eachdataset has a different number of features that are used toevaluatetheproposeddiseasepredictionsystem.

*3.2.3 DiseasePredictionModule*

The disease prediction module has controloverthe entirearchitectureoftheproposeddiseasepredictionsystem.Itana lyzes and processes the queries received from the userinterfacemoduleandsendsthediseasepredictionresultsback to the user interface module. The major responsibility ofthismoduleistotrainthemodelusingallthepossiblecombinatio ns of available feature selection and classificationalgorithms.Itdoessobyutilizingthreeimportantco mponentsasdecisionmanager,rulemanager,andrulebase, which are used to perform various tasks for effectivediseaseprediction.

*3.2.3 FeatureSelectionModule*

The feature selection module is responsible for performingdata preprocessing effectively. Here, two operations such asfeaturesubsetgenerationandsubsetevaluationsareperformed to select the optimized feature set. In the featureselectionmodule,threenewlyproposedfeatureselectional gorithmsareusedsuchasEGWO-FSA,GBCOA,andIFSA.

These algorithms have been applied for performing thefeatureselectioneffectively

In GBCOA, the binary cuckoo optimization algorithm is usedto perform the subsetselectionoperation, and the geneticalgorithm is used to perform a subset evaluation operation toselect the best optimal feature set. EGWO-FSA is applied foridentifying the contributed features using an enhanced graywolfoptimizer.TheIFSAalgorithmisimplementedbycombi ning the Intelligent Conditional Random Field (ICRF)andtheLinearCorrelationCoefficientbasedFeatureSelec tion(LCFS)algorithmscalledICRF-LCFS.Here,features are grouped based ondistance metrics. Then, theLCFSandICRFareusedtoselectthemostsignificantfeatures that are useful for making an effective decision ondisease-affectedrecordstoimproveclassificationaccuracy.

*3.2.4 ClassificationModule*

The classification module categorizes the data according tothe features extracted from the feature selection module. Theclassificationmodule trains deeplearning modelssuchasnovelC-RNN,newT-CNN,andthestandardDBNforgenerating classification rules. In C-RNN, the convolutionallayerisintegratedwiththeclassicalRNN.Italsoinc orporatestheGRUcellswiththerecurrentlayerstohandlethetimes equencedata.InT-CNN,thetemporalfeatures are considered while deciding on the disease dataset.Moreover, the DBN is also incorporated in the classificationphaseforclassifyingthedataeffectively.Thepropos edclassifiers in this module categorize the data as "normal,""susceptible,"or"diseased,"with thediseasebeing eitherdiabetic, cancer, or heart disease. Furthermore, the proposedclassifiers canaccuratelypredictthediseaseseveritylevel.

*3.3 WORKFLOW OF THE PROPOSED DISEASEPREDICTIONSYSTEM*

The sequence of operations involved in the proposed diseasepredictionsystemisillustratedinFigure3.2.Theuser'squery or patient medical reports will be sent to the decision managerthrough the IoT device. Rule manager generates nine classifierssuch as EGWO-FSA & DBN, EGWO-FSA & C-RNN, EGWO-FSA & T-CNN, GBCOA&DBN, GBCOA& C-RNN, GBCOA&T-CNN,IFSA&DBN,IFSA&C-RNN,andIFSA&T-CNNby combiningallpossiblecombinationsofproposedfeatureselection and classification algorithms. Also, the rule managergeneratestherulesbytrainingalltheclassifiersusingthe availabledatasets.Therulemanagerstoresandfrequentlyupdatestherulesintherulebasewithitsnewpredictionaccuracy.

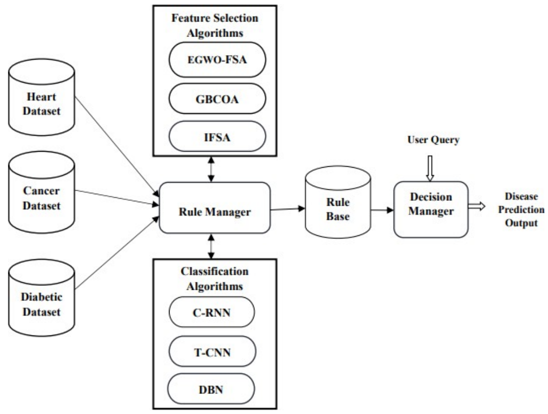


**Figure3.2Workflowof ProposedDiseasePredictionSystem**

The rule base holds all rules generated by the rule manager. Thedecision manager will analyze the patient's data using the rulesavailable in the rule base and selects the optimized rule with thehighestdiseasepredictionaccuracy.Thedecisionmanagerdecidestheinputdataandproducestheoptimizeddiseaseprediction outputasaresultfortheuser.

*3.4 PROPOSEDMETHODOLOGIES*

This research has introduced a new disease predictionsystemwith the use of feature selection and deep learning algorithms. Ithas been carried out with three different techniques with differentcombinationsof feature selectionand deeplearning algorithms.In the first technique, a disease prediction system is developedwiththecombinationofthenewEnhancedGreyWolf Optimization-based Feature Selection Algorithm and Deep BeliefNetwork(EGWO-FSA&DBN).Thesecondtechniqueisdesignedusing the new GeneticBinary Cuckoo OptimizationAlgorithmandthenovelConvolutionalRecurrent NeuralNetwork (GBCOA & C-RNN) for efficiently identifying diseasesand their severity level. The third technique implements a noveldiseasepredictionsystemthathasbeendevelopedusingthe IncrementalFeatureSelectionAlgorithmandConvolutionalNeural Network with Temporal features (IFSA & T-CNN) forpredictingdiseaseswithlesscomputationtime.

*3.4.1 DiseasePredictionSystemUsingGBCOAandC-RNN*

thistechniqueintroducesanoveldiseasepredictionmodel to predict diabetes, cancer, and heart diseases. This modelapplies a newly developed Genetic Binary Cuckoo OptimizationAlgorithm and the Convolutional-Recurrent Neural Network topredict the diseases. The GBCOA algorithm is used to select themostsignificantfeaturesthatareappliedforenhancingtheclassification accuracy of the C-RNN model. The CRNN modelcombines the convolutional and recurrent layers to perform bothsequential processing and multiclass classification for effectivedisease prediction. The Recurrent layerof the C-RNN modelconsistsofmultipleGRUwithtwotypesofgatesnamelyrelevantandupdategatestohandlethetemporalfeatures.

*3.4.2 DiseasePredictionUsingIFSAandT-CNN*

Inthistechnique,anoveldiseasepredictionsystemforpredicting diseasessuchasdiabetes,heart,andcancerisproposed. This methodology incorporates a newly proposedfeatureselectionalgorithmcalledIncrementalFeatureSelectionAlgorithmandatemporal-ConvolutionalNeuralNetworktopredictthediseases.TheproposedIFSAalgorithm combines the ICRF and LCFS methods. In IFSA,the ICRF is used to group the features based on their distancefromoneanother.Thecorrelationcoefficientvalueiscomputedaftergroupingthefeaturesusingtherelatedformulae, and it also selectsthe most relevant and usefulfeatures to improve classification accuracy. Then, LCFS wasused to evaluate and select the cluster with optimized featuresthat are useful in making an effective decision on disease-affectedrecords.

## 4. CONCLUSIONANDFUTUREWORK

This research work has been proposed and implemented asthreedifferentmethodologiesasEnhancedGreyWolfOptimization-based Feature Selection Algorithm with DeepBeliefNetwork,GeneticBinaryCuckooOptimizationAlgorithmwithConvolutional-RecurrentNeuralNetwork,and Incremental Feature Selection Algorithm with TemporalConvolutional Neural Network. The overall architecture ismadeupofvariousfeatureselectionandclassificationalgorithms that have been proposed. Finally, it is used as adisease prediction system, capable of predicting fatal diseasessuchas diabetes, heartdisease,andcancer.

Inthe EGWO-FSA&DBNmethodology,anewdiseaseprediction system has been proposed and implemented withtheincorporationofIoTandDeepLearningtechniques.Here, a new feature selection algorithm called EGWO-FSA isimplementedtoachievebetterclassificationaccuracythroughDBN.Thisdiseasepredictionsystem,predictsdisease and its severity level according to the inputs that arecollected through IoT devices. Experiments were carried outto evaluate the proposed methodology using datasets fromheart,diabetes,andcancerdiseases.Onvarioustypesofheart, diabetes,andcancerdatasets,thismethodologyachievedanoverallpredictionaccuracyof95.05%.Furthermore,itcategorizespatientinformationbasedondiseasetypesandseveritylevels.

IntheGBCOA&C-RNNmethodology,anewdiseaseprediction model has beendeveloped and implemented topredictthediseasessuchasheart,diabetes,andheartdiseases.ThisnewmodelappliesanewlydevelopedGBCOA algorithm and C-RNN model to predict the disease.The major contributions of this work are the introduction ofthe feature selection algorithm with a deep learning modelwhich combines the convolutional layerand recurrent layerto perform feature reduction and sequential. Moreover, it isuseful for selecting the contributed attributes that are appliedtoimproveclassificationaccuracy.Inaddition,theapplicationoftheproposedGBCOAfeatureselectionalgorithmandConvolutional-RecurrentNeuralNetworkmodel with multiple GRU cells is useful for performing themulticlass classification on disease datasets. The proposeddiseasepredictionmodelachieved95%overalldiseasepredictionaccuracyonheart,cancer,anddiabeticdisease datasets. Finally, this disease prediction model proved as betterthan other models in terms of better prediction accuracy with lesscomputationtimeforperformingtheclassification.

For making decisions on the records, time is taken into accountand applied to the soft-max layer of T-CNN. At the end of theclassification process, the normal records and disease-affectedrecords in the heart, diabetic, and cancer disease datasets can beidentified. Furthermore, this disease prediction system is usefulforlearningaboutthediseaseanditsseveritylevel.Thistechnique has been tested using standard medical datasets suchas diabetes, heart, and cancer disease datasets. The experimentshave beenconducted forevaluating the model and achieved97% accuracy as an overall prediction accuracy for the diabetic,heart, and cancer datasets. Finally, this technique is proved asbetter in terms of prediction accuracy than the existing diseaseprediction model which uses deep learning algorithms and otherclassificationalgorithms.Theproposeddiseasepredictionmodelistakenless timeforperformingclassification.

In this system, the user's query or patient medical reportswill be sent to the decisionmanager through anIoT device.Rule manager generates nine classifiers such as EGWO-FSA &DBN,EGWO-FSA&C-RNN,EGWO-FSA&T-CNN,GBCOA&DBN,GBCOA&C-RNN,GBCOA&TCNN,IFSA & DBN, IFSA & C-RNN, and IFSA & T-CNN by combiningallpossiblecombinationsofproposedfeatureselectionandclassificationalgorithms.Furthermore,therulemanagergenerates the rules by training all of the classifiers withtheavailabledatasets.Therulemanagerstoresandfrequentlyupdates thepredictionperformance metrics scoresof the rulesin the rule base. All rules generated by the rule manager arestored in the rule base. The decision manager must identify thebest classification rule for better prediction based on the user'srequest.

Each algorithm is capable of performing well on a variety ofdatasets.Eventhoughallpossiblefeatureselectionandclassificationalgorithmcombinationsperformedwellon thediabetic dataset, heart dataset, and cancer dataset, with goodprediction accuracy and less computational time. The precision,accuracy,recall,andf-measurescoreoftheproposedalgorithms are used to assess their disease prediction accuracy.Accordingtouserdata,thebestcombinationoffeatureselectionandclassificationalgorithmisidentifiedforeffectively predicting diseases.Finally,theproposeddiseasepredictionsystempredictsdiseasesandtheirseverity levelswith minimal computation time. The proposed model achievedan optimized disease prediction accuracy of 97.8%, 98.4%, and97.5% on heart, diabetic, and Cancer datasets respectively. Alsoobtained was the reduced computation time of 0.41sec, 0.89sec,and0.53seconheart,diabetic,andCancerdatasetsrespectively.

## 5. REFERENCE

[1]. Abbas Mardani, Robert E Hooker, SeckinOzkul, Sun Yifan,MehrbakhshNilashi,HamedZamaniSabzi&GohChinFei2019, ‘Application of decision making and fuzzy sets theory toevaluatethehealthcareandmedicalproblems:Areviewofthree decades of researchwith recent developments’, ExpertSystems withApplications,vol.137, pp.202-231.

[2]. Abbas Rezaianzadeh, Maryam Dastoorpoor, Majid

Sanaei,CirruseSalehnasab,MohammadJavadMohammadi&
AliMousavizadeh2020,'Predictorsoflengthofstayinthecoron
arycareunitinapatientwithacutecoronarysyndrome

based on data mining methods', Clinical Epidemiology andGlobalHealth,vol.8,no.2,pp.383-388.

[3].AhmedMAbdel-Zaher&AymanMEldeib2016,'Breastcancerclassificationusing deepbeliefnetworks,ExpertSystems WithApplications,Vol.46,pp.139–144.

[4].AksacA,DemetrickDJ&OzyerT,2019,'BreCaHAD: a dataset forbreast cancer histopathologicalannotationanddiagnosis',BMCResNotes12, 82.https://doi.org/10.1186/s13104-019-4121-7.

[5].AlminaKalkan,JohanBodegard,JohanSundström,BodilSvennblad, Carl Johan Östgren, Peter Nilsson Nilsson,GunnarJohansson&MattiasEkman2017,'Increasedhealthcare utilizationcosts following initiationofinsulintreatmentintype2diabetes:Along-termfollow-upinclinical practice', Primary Care Diabetes, vol. 11, no.2, pp.184-192.

[6].AmalRannenTriki, Matthew B Blaschko,YoonMoJung,SeungriSong,HyunJuHan,SeungIlKim&ChulminJoo 2018, 'Intraoperative margin assessment ofhumanbreasttissueinopticalcoherencetomographyimages using deep neural networks', Computerized MedicalImagingandGraphics,vol.69, pp.21–32.

[7].AminUllah,JamilAhmad,KhanMuhammad,MuhammadSajjad&SungWookBaik2018,'ActionRecognition in Video Sequences using Deep Bi-DirectionalLSTM with CNN Features', IEEE Access, vol.6, pp. 1155-1166.

[8].AminUllah,KhanMuhammad,Ijaz-Ul-Haq&SungWookBaik 2019, 'Action recognition using optimized deepautoencoder and CNN for surveillance data streams of non-stationaryenvironments',FutureGenerationComputerSystems,vol.96,pp.386-397.

[9]. ArokiaJesuPrabhu, L, SudhakarSengan, Kamalam,GK,Vellingiri,J,JagadeeshGopal,PriyaVelayutham&Subramaniyaswamy,V2020,'MedicalInformation Retrieval Systems for e-Health Care RecordsusingFuzzyBasedMachineLearningModel',MicroprocessorsandMicrosystems,ArticleNo.103344.https://doi.org/10.1016/j.micpro.2020.103344.

[10]. Baiju R Shah & Lorraine L Lipscombe 2015, 'ClinicalDiabetesResearchUsingDataMining:ACanadianPerspective',CanadianJournal of Diabetes,vol.39, no.3,pp. 235-238.

[11].Bengio,Y,Courville,A&Vincent,P2013,'Representation learning: A review and new perspectives',IEEETransactionsonPatternAnalysisandMachineIntelligence,vol.35, pp. 1798–1828.

[12]. BerhanuAlemayehu, Jinan Liu, SwapnilRajpathak&SamuelSEnge2017,'Healthcareresource useandassociated costs of hypoglycemia in patients with type 2diabetesprescribedsulfonylureas',JournalofDiabetesComplications,vol.31,no.11,pp.1620-1623.

[13].BingLiu,ChunruWan&Wang,L,P2006,'Anefficientsemi-unsupervisedgeneselectionmethodviaspectralbiclustering',IEEETransactiononNano-Bioscience,vol.5,no.2, pp.110-114.

[14].CamillaGjellebæk,AnnSvensson,CatharinaBjørkquist, NinaFladeby&KerstinGrunden2020,'Managementchallengesforfuturedigitalizationofhealthcareservices', Futures,vol.124,ArticleNo.102636.

[15]. Chao Li, Xiangpei Hu &Lili Zhang 2017, 'The IoT-basedDisease Monitoring System for Pervasive Healthcare Service',ProcediaComputerScience,vol.112, pp.2328-2334.

[16].Cho,BH,Yu,H,Lee,J,Chee,YJ,Kim,IY&Kim,SI 2008,'NonlinearSupportVectorMachineVisualizationforRisk Factor Analysis Using Nomograms and Localized RadialBasis Function Kernels,' in IEEE Transactions on InformationTechnologyinBiomedicine,vol.12,no.2, pp.247-256.

[17].Chun-SongHu,Qing-HuaWu,Da-YiHu&TengizTkebuchava2017,'Novelstrategieshaltcardiovascular,diabetes, and cancer strips', Chronic Diseases and TranslationalMedicine,vol.3,no.3, pp.159-164.

[18].DebarpitaSantra,SwapanKumarBasu,JyotsnaKumarMandal &SubrataGoswami2020, 'Roughsetbased latticestructureforknowledgerepresentationinmedicalexpertsystems:Lowbackpainmanagementcasestudy',ExpertSystemswithApplications,vol.145,ArticleNo.113084.

[19]. Deepika, M &Kalaiselvi, K 2018, 'A Empirical study onDiseaseDiagnosisusingDataMiningTechniques,'2018Second International Conference on Inventive CommunicationandComputationalTechnologies(ICICCT),Coimbatore,pp.615-620.

[20].Dianlong,Xindong,Limin,Song,Zhen,ChuanandQiusheng2019,'OnlineFeatureSelectionforStreamingFeaturesUsingSelf-AdaptionSliding-WindowSampling',IEEEAccess,vol.7, pp. 16088-16100.

[21].Dominic,V,Gupta,D,Khare,S&Aggarwal,2015,'Investigation of chronic disease correlation using data miningtechniques,' 2nd International Conference on Recent AdvancesinEngineering&ComputationalSciences(RAECS),Chandigarh,pp.1-6.

[22].Enas,MF&ElHouby2018,'Asurveyonapplyingmachinelearningtechniquesformanagementofdiseases',JournalofAppliedBiomedicine,vol.16,no.3,pp.165-174.

[23]. Eroglu, D, Y&Kilic, K 2017, 'A novel hybrid geneticlocal search algorithm for feature selection and weighting withanapplicationinstrategicdecisionmakingininnovationmanagement',InformationSciences,vol.405,pp. 18-32.

[ 24]. FajrIbrahimAlarsan&MamoonYounes 2019, 'Analysisand classification of heart diseases using heartbeat features andmachine learning algorithms', Journal of Big Data, vol.6, no.81,pp. 1-15.

[25]. FazelZarandi, MH, Soltanzadeh, S, Mohammadi, A &Castillo,O2019,'Designingageneraltype-2fuzzyexpertsystem for diagnosis of depression', Applied Soft Computing,vol.80, pp. 329-341.