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RESEARCH PAPER

Techniques of Explainable Artificial Intelligence and Machine Learning in Digital Mental Health Intervention

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ABSTRACT

The objective of this study is to examine the use of explainable artificial intelligence (XAI) for gathering and analyzing health-related data in medical services applications, particularly in predicting outcomes in mental health care. Artificial Intelligence (Al) is increasingly utilized in medical services and wearable technologies, such as Fitbits. Strategies in the field of explainable Al (XAI) aim to clarify the predictions made by Al systems, enhancing their application in health-related contexts. Data was collected from 970 individuals, incorporating clinical and sociodemographic information. The analysis focused on factors such as self-reported motivation, the type of reference (self vs. healthcare provider), and the Work Productivity and Activity Impairment Questionnaire. Additionally, pre-treatment scores from the Patient Health Questionnaire-9 and General Anxiety Disorder Screener-7 were evaluated. The study identified that self-reported motivation and the specified reference type significantly contributed to predictive outcomes. The irregular forest model achieved an accuracy of 0.71 for the test set, with a base rate of 0.67, an AUC of 0.60, and a p-value of 0.001. Adjusted accuracy was noted at 0.60, indicating a significant ability to predict reductions in anxiety and depressive symptoms. To improve the personalization and effectiveness of mental health care, it is essential to advance predictive models that accurately evaluate individual responses to therapeutic interventions.

KEYWORDS Depression, Digital Mental Health, Explainable AI, General Anxiety Disorder, Machine Learning, Outcome Prediction, Personalized Connected Healthcare, Precision Psychiatry, Smart Healthcare

Introduction

Artificial intelligence (AI) is revolutionizing healthcare by enabling the collection and analysis of personal health data through smart wearables like Fitbits. These devices can predict potential health issues when integrated with healthcare applications. The integration of Al and wearable technology enhances various aspects of smart healthcare, with a particular focus on explainable AI (XAI) to clarify predictions made by Al systems (Pawar, 2020).

Literature Review

Regardless of essential paintings nearby, the reception of such fashions in down-to-earth applications, for example, scientific choices emotionally supportive networks has been tested (Shortliffe, 2018).Logical AI is new, but the foundation of the exploration returns to the mid-Nineteen Seventies with paintings at the explanation of preference emotionally supportive networks with comparative inspirations to now. In spite of labor to date, the continuous issues display a probable confuse among the paintings being completed and the targets of the AI applications (Gunning, 2019).

Overview Of Artificial Intelligence In Digital Interventions

This is being completed in several ways, like health correspondence, augmented reality, facet effect, and biomarker observing, mental health emergency, superior phenotyping to foresee results, and personalization of content. ELIZA become custom designed to solution in mild of a Rogerian psychotherapeutic methodology, searching through customer enter for watchwords and later on making use of a general in view of those catchphrases to present a reaction. One survey noticed that 39% of health chatbots zeroed in on mental health issues and some other audit introduced that forty one emotional health chatbots have been created in 2019 alone [Milne-Ives, 2020].

Explainable Artificial Intelligence (XAI)

Discovery techniques are version skeptic and may be implemented all of the extra for the maximum part, even as white-field strategies regularly require the calculation of version inclinations. As a preference to post-hoc explanation techniques, fashions may be made to be interpretable in any case. Thusly, some strategies have tried to learn "fashions," or delegate fashions that seize statistics approximately the basic facts circulation[Hu, 2022].

Table 1
Literature Review

Name of Paper	Year of Publish	Findings	Author Name
Artificially intelligent chatbots in digital mental health interventions: a review	2021	Happify Health's AI chatbot, Anna, serves as a case study for discussion of potential challenges and how these might be addressed, and demonstrates the promise of chatbots as effective, usable, and adoptable within DMHIs	Boucher, E. M., Harake, N. R., Ward, H. E., Stoeckl, S. E., Vargas, J., Minkel, J., ... & Zilca, R.
Athlete Psychological Resilience and Integration with Digital Mental Health Implementation Amid Covid-19	2021	Digital mental health implementation is a logical next step for advancing the construct of athlete psychological resilience towards complementing an effective prevention and early intervention.	Balcombe, L., & De Leo, D.

Systemic and Practical Issues

The viability of a automatic degree with digital mentors for mental behavior treatment changed into investigated in a subjective report it supposed a lot to view approaches for customers as drawn to and in a while reliably drew in with the automatic degree [Balcombe, 2021]. Studies currently cannot appear to put out fashions of mental clinical offerings framework viability and development from coordinating automatic emotional wellbeing, e.g., associate longitudinal examinations that examine flexible screening and following gadgets conveyed in a half-breed version of care. Finding concord amongst versatility and fidelity changed into referred to be tremendous with inside the proposed genuine trying out of a paraprofessional automatic emotional wellbeing guide version [Boucher, 2021].

New Progress

The COVID-19 pandemic multiplied the want to counter the medical and monetary effects of intellectual persistent illness thru association of assistive, precaution, and useful preparations (e.g., net primarily based totally records assortment apparatuses, automated degrees and applications[Wies, 2021]. The property predicted to direct the determination, execution, and evaluation of AI calculations and man-made reasoning degrees are handy on-line for public use. A longitudinal observational evaluation checked the worthiness and viability of AI remedy for uneasiness and sadness [Torous, 2020].

Ongoing Problems

Computerized emotional well-being execution in scientific settings requires care and readiness, along a better comprehension of specialised and scientific norms, to extend viability, approval, and consumer-targeted plan in addition to to counter ethical worries [16]. Partners want a pleasant framework and competencies base in addition to the ethical route with inside the flip of events, organization, and the board of automated mental well-being arrangements . The dumbfounding endeavors to propel evidence and execution of automated mental well-being brought about the concept for recreation-primarily based totally studies [Wies, 2021].

Approaches

Advanced emotional nicely-being administrations are handy at the net (by way of paintings areas, mobileular phones, and packages), inclusive of via net go to and companion guide gatherings in addition to by means of telephone , to give emergency guide, psychotherapy, guiding, intellectual medicines, well-being advancement, schooling, and anticipation in addition to assist for recuperation. A net-primarily based totally evaluate of the usage of automatic information and correspondence improvements in intellectual directing formerly and in the course of a COVID-19 lockdown discovered commonly speaking strength with inside the usage of improvements and on line mediations, with most specialists noticing more or less a comparable consumer contribution/adherence rates. A speedy survey at the viability of automatic mental health mediations for human beings with an associated continual sickness (intellectual or doubtlessly physical) discovered digital intercessions and electronic mail had the most reviews of development but similarly examinations had been anticipated previous to making greater grounded tips at the pertinence for youth.

Digital Mental Health For Young People

Just a little quantity of automated tiers is evidence-primarily based totally all of the greater must be regarded approximately the viability of the form of management given the goal subpopulation and the continued norm of care. A conference for an evaluation concentrates at the viability of training and preparing teens mental health care clinicians laid out that the reception and enhancement of specialized preparations are important to be used in widespread medical practice. This paper proposes the contribution of XAI techniques to introduce the reasoning at the back of forecasts made through AI-primarily based totally frameworks to the companions in clinical offerings to accumulate the accompanying advantages: Expanded straightforwardness: As XAI techniques make feel of why an AI framework confirmed up at a specific choice, it increments straightforwardness with inside the way in which AI frameworks works and might set off multiplied ranges of trust [Whittle, 2018].

Table 2
Literature Review

Title of paper	Methodology Used	Results	Year of publication& Author Name
Learning the Mental Health Impact of COVID-19 in the United States with Explainable Artificial Intelligence	Through initial statistical analysis followed by Bayesian Network inference, we have Identified key factors affecting Mental health during the COVID pandemic. Integrating	Using the Bayesian Network Model, we found that People with chronic medical conditions or mental illnesses are more prone to mental disorders during the COVID age. The new realities of working from home, home-schooling, and lack of	Jha, I. P., Awasthi, R., Kumar, A., Kumar, V., & Sethi, T. (2020).

	Bayesian networks with classical machine learning approaches lead to effective modeling of the Level of mental health.	Communication with family/friends/neighbors induces mental pressure.	
A Machine Learning Approach to Understanding Patterns of Engagement With Internet-Delivered Mental Health Interventions	Silver Cloud Health is an evidence-based, online, self-administered platform that delivers iCBT alongside feedback from trained human supporters.25,26 We used deidentified data from 67 468 patients on the Space From Depression and Anxiety treatment program between January 31, 2015, and March 31, 2019.	My Worries: OR, 1.34; 95% CI, 1.12-1.61; P = .002; Anxious Thoughts and Worry Quiz: OR, 1.45; 95% CI, 1.21-1.74; P < .001; Mood Monitor: OR, 1.23; 95% CI, 1.05-1.45; P = .01; and Understanding My Situation: OR, 1.22; 95% CI, 1.04-1.42; P = .001), but less likely to do activities such as Activity Scheduling (OR, 0.57; 95% CI, 0.48-0.68; P < .001) and Activities List (OR, 0.58; 95% CI, 0.49-0.69; P < .001)	Chien, I., Enrique, A., Palacios, J., Regan, T., Keegan, D., Carter, D & Belgrave, D. (2020).

Mental Models For Explainable Artificial Intelligence

The putting is like that of the intellectual version: who's the horde of the rationale, what's the language this is getting used to grant, and what's the justification for the version. An rationalization of a version is a verbalization or reformulation of the version in an different medium that may be granted to others.3. A version is regular if a first rate rationalization of the version may be made [Merry, 2021].

Material and Methods

In this paper, we recommend to apply existing XAI fashions related with medical statistics to get extra blessings in AI-based systems. As displayed in Figure 1, the proposed method is got-ten a deal with on because the going with:

1. Smart medical attention programs get the prosperity records of people and use the pre-organized AI fashions to expect the chance of specific peculiarities.

2. Diseases.

3. The assumptions near the prosperity statistics are utilized by XAI techniques (4) to supply motives.

4. These motives may be penniless down with the assist of a clinician's statistics. This exam will interact the endorsement of estimates made via way of means of the AI version via way of means of clinicians to allow straightforwardness.

5. If assumptions are correct, then, motives near medical statistics may be used to supply important encounters and recommendations.

6. If assumptions are wrong, then, at that point, the valid irregularity amongst motives and clinician's statistics may be used to observe elements for mixed-up conjectures and allow development in the conveyed AI version.

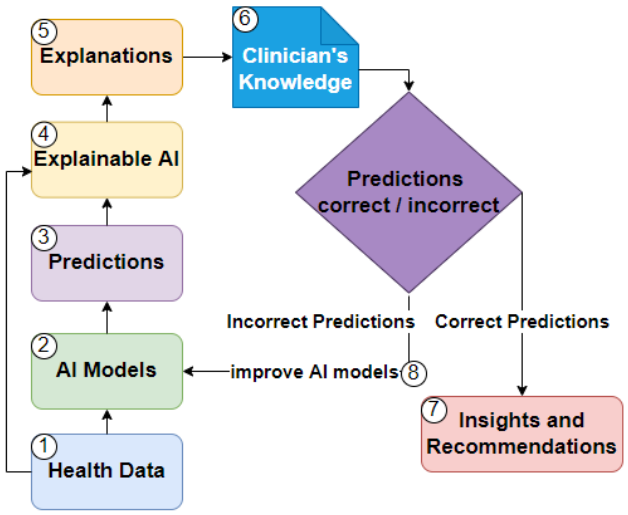

Figure 1 Generating insights using XAI and Clinical expertise

A version usage of this concept could be if there's an extension with inside the glucose level, clinicians could be dispatched a file nearby the beat, internal warmth level, and calorie usage data. A XAI version will discern out that the part on the whole obligated for this assumption is calorie usage. Clinicians can then studies the functions and advice becoming rugs/practices n solicitation to make bigger the upside of XAI the reasons made ought to be huge and provided fairly as an example GUI for the end-customers that may be clinicians having information with inside the scientific place or ordinary individuals [Balcombe, 2021].

Intervention

The intervention takes someplace in the quantity of eight and 12 weeks, with every week having a critical point, for example, relaxation this is regarded out for in psycho tutoring bills in addition to sports which are proposed to human beings dependably. People that entered the MHP thru their boss with the aid of using becoming a member of disengaged are implied as 'self-references'. Different human beings are recommended the MHP with the aid of using medical blessings concern depend experts. [Hornstein, 2021].

Sample

Individuals who in no way commenced this system, as assessed through interest with inside the application , in addition to the ones without a PHQ-nine and GAD-7 motivator for the starting of this system , have been restricted. For putting in the estimation, information from all people that commenced this system earlier than 29 June 2020 changed into used, this finished a educate set of 970 people. The greater 279 people that commenced this system after that have been used as a take a look at set.

Outcome

The cut-off for the final results changed into both basically a 5-factor decline on the PHQ-nine or conceivably a 4-center lessening of the GAD-7, that are the 2 depictions of the inconsequential traits for primary development of aspect effects [Löwe, 2004,Toussaint, 2020]. Likewise, because the scientific heading is usually equal (as an example touch a affected person or now no longer), a twofold estimate has all of the earmarks of being via way of means of and big usable in line with an expert's factor of view. For the folks that did not end a GAD-7/PHQ-nine have a look at near the finishing touch of this system, the remaining discernment changed into handed ahead on to technique secondary impact

decline, which changed into what changed into taking place for 37% of the people. [Hornstein, 2021].

Data Preprocessing And Training

While a couple of essential statistics cleaning, for instance, dichotomizing elements as the answer changed into executed earlier than this , maximum preprocessing and the real readiness of computations had been completed with scikit-analyze 0.22. This changed into executed to store the take a look at set for a one-time body define closing evaluation of the creation of the computation on new statistics, to keep away from overfitting the take a look at statistics. Moreover, this appears to be the genuine sample of executing and the usage of a ML approach, regarding those judgments of the computation have to be picked earlier than assumptions are made and used for any in addition intercession. [Hornstein, 2021].

Table 3
Data Sources, Pre-Processing Steps And Missing Data.

Variable(s)	Source	Preprocessing	Missing Data (%)
Sex	Participants self-disclosure	while 'Others' Was Not preferred At All, Sex Was Dichotomized	10%
Age	Participants self-disclosure	Calculated as (Year of Sign-up –Birth Year)	2%
Referral	Entered with the resource of use of care coordinator at the same time as scrutiny eligibility of participants'.	Dichotomized to 'self-referral' and 'healthcare professional referral'.	3%
Payment	Entered with the resource of use of the care coordinator at the same time as checking eligibility of participants'.	Dichotomized to 'Free' and '(Co)-Pay'.	14%
Motivation	Participants' self-disclosure in intake call	-	5%
Medication	Participations self-disclosure, clarified intake call	Dichotomized to 'Yes/No'	20%
PHQ-9 baseline	Questionnaire with inside the app earlier first name with the therapist.	Single gadgets brought up for overall score.	Score: 0%. Individual gadgets: 12%
GAD-7 baseline	Questionnaire supplied in the app earlier than first name with the therapist.	Single gadgets brought up for overall score..	Score: 0%. Individual gadgets: 10%
WPAI	Questionnaire presented in the app before first call with the therapist.	Scores calculated out of the items as suggested.	18 – 40 %
Burnout score	Participants self-disclosure	-	36%
History of trauma	Participants self-disclosure clarified in intake call	Dichotomized to 'Yes'/'No'. 'Unknown' was set NA.	33%
Major depressive episodes	Participants self-disclosure, clarified in intake call.	-	36%
Psychiatric hospitalizations	Participants self-disclosure, clarified in intake call.	-	29%
Suicide attempts	Participants self-disclosure, clarified in intake call.	-	29%

Here, direct suggest attribution turned into differentiated and the iterative imputer turned into accomplished in SK-learn, as an detail of the cross-endorsement framework. For the maximum uplifting estimation, hyper-boundary tuning turned into accomplished the usage of an exhaustive lattice search, in addition to univariate function warranty the usage of learns Select K Best. For the RF, going with hyper parameters turned into attempted: various trees , the maximum outrageous importance of the trees , the fine variety of components , and the bottom variety of exams predicted to segment a center and required variety of exams in a leaf.

Table 4
Full sample characteristics, as well as for responders and non-responders.

	Full sample (n= 1236)	Response (n=751)	No Response (n=485)
Female sex	76.3%	79.2%	71.9%
Age(years)	38.9 (11.3)	39.4 (11.5)	38.4 (11.0)
PHQ-9 baseline score	12.0 (5.5)	12.5(5.6)	11.3(5.4)
GAD-7 baseline score	11.3(4.6)	12.0(4.4)	10.1(4.6)
PHQ-9 final score	7.8 (5.7)	5.6 (4.1)	11.3(5.9)
GAD-7 final score	7.2 (4.8)	5.2(3.4)	10.1(5.1)
PHQ-9 change over programme	-4.2(5.3)	-6.9(4.8)	-0.0(2.9)
GAD change over programme	-4.1(4.9)	-6.8(4.3)	-0.0(2.1)
WPAI absenteeism	10.7(22.9)	11.1(22.8)	10.1(20.7)
WPAI presenteesism	45.7(26.4)	46.1(25.8)	44.9(27.5)
WPAI work productivity loss	49.8(28.2)	50.5(27.5)	48.4(29.2)
WPAI activity impairment	51.6(25.6)	50.1(25.6)	52.7(25.6)
Burnout score	3.0(1.0)	3.0(1.1)	2.9(1.1)
Motivation score	8.5(1.2)	8.6(1.2)	8.3(1.2)
History of major trauma	39.8%	39.8%	39.6%
Episodes of major depression	2.0(2.7)	1.9(2.6)	2.1(2.8)
Psychiatric hospitalizations	0.1(0.4)	0.07(0.4)	0.05(0.3)
Suicide attempts	0.1(0.4)	0.09(0.4)	0.06(0.4)
Medication (yes/No)	42.5%	41.5%	43.6%
Type of referral (self vs. healthcare professional	71.7%	74.3%	67.5%

The correction encouraged through Nadeau and Bengio [88] become used to control the left out doubt of possibility whilst trying out differentiations of classifiers over cross-endorsement. Following the concept of Bouckaert and Frank, the check become resolved in extra of a ten instances repeated 10-wrinkle cross-endorsement method to make sure reproducibility of the results [Hornstein, 2021].

Testing Of Algorithms Performance And Feature Importance

The choice for this type of the time sensitive educate-check break up changed into made as this seems to be the way through which the estimation might sincerely be used all matters being equal (such as antique records to make assumptions for as of past due shifting toward people) and therefore including to the outside authenticity of the methodology. Execution changed into evaluated through unevenly transforming the symptoms and symptoms of the educate records and the check records for more than one instances and on this manner differentiating the precision got here to at the permuted records with the precision of the primary records. In view of the intercorrelations, PHQ-9 things, Stray 7 things and WPAI things were gathered into one spot.

Results and Discussion

Cross-Validation

A RF classifier turned into picked because the best-appearing calculation over the cross-approval strategy (Figure 2). RF arrived at a median ROC AUC of 0.64 (SD =0.04). The assist vector system scored 0.63 (SD =0.06), the calculated relapse 0.61 (SD =0.03) and the credulous Bayes 0.60 (SD =0.04). These exhibition measurements had been reached even as

making use of scikit-learn's simple imputer.

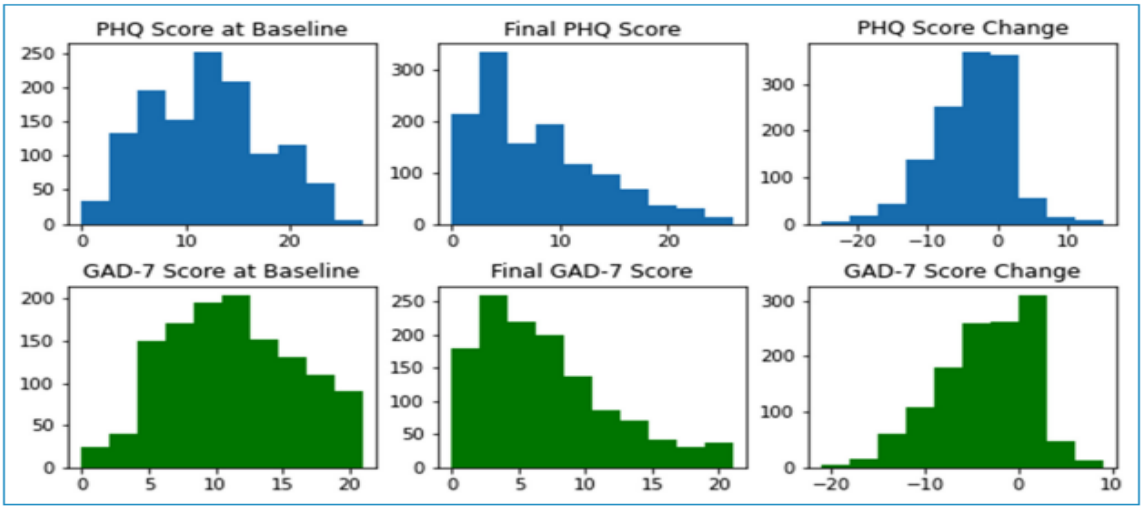

Figure 2Distribution of PHQ-9 and GAD-7 values on the baseline (left) of the final score (middle) and of the change (right).

The utilization of the iterative imputer expanded the presentation marginally for the strategic relapse (0.62, SD =0.03), however didn't impact the exhibition of the gullible Bayes and dwindled the presentation of the SVM (0.62, SD =0.05) and the RF (0.63, SD =0.05). In this manner, the fundamental imputer became applied for the last expectancies at the take a look at set. Hyper-parameter tuning and component willpower became assessed for the RF because the high-quality acting calculation. Lessening the amount of things did not enlarge the exhibition in any case, conversely, emphatically brings down the amount of signs and adversely affected ROC AUC. For instance, using sixteen elements selected with the aid of using univariate spotlight willpower delivered approximately a median ROC AUC of 0.61. As none of the investigated mixes of limitations prompts.

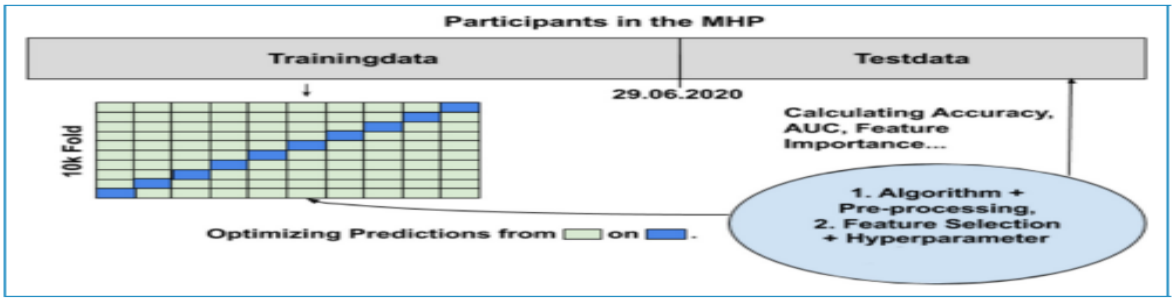

Figure 3. Visualization of the training of the machine learning (ML) algorithm. The best performing solution over a 10-fold cross-validation

Obviously further developed execution, the default boundaries were utilized for anticipating the treatment reaction of the test set. At last, the exhibition of the strategic relapse was contrasted and the presentation of the first-rate appearing calculation the RF, uncovering a outstanding difference in their ROC AUC score (p=0.04). Figure three appears on the exhibition of the four specific calculations through plotting their ROC AUC bends.

Test Set Performance

Consequently, this paper researched the prescient execution of ML calculations for the effects of a consultant upheld DMH intercession that specialize in disappointment and tension. Other than PHQ-nine and GAD-7 qualities, a self-file of inspiration, the WPAI values, in addition to the form of reference into this system delivered maximum to the prescient

pressure of the calculation. Therefore, this paper successfully exhibited the pertinence of a ML-primarily based totally end result expectation approach in DMH, at the same time as having a massive instance length and excessive outdoor the legitimacy, due to records coming from a proper international DMH program.

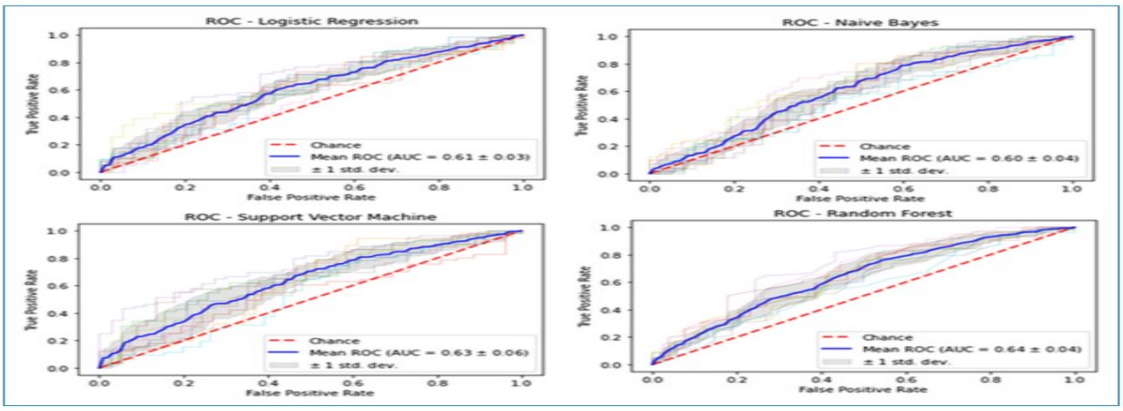

Figure 4. Comparison of the performance of four algorithms over the cross-validation procedure.39 Thin lines represent performance per

Notwithstanding the general moderate precision of the model determined in the ongoing examination, the picked approach had a few different impediments In the primary place, because of the dataset coming from a naturalistic setting, there has been quite a few lacking data. This ought to have delivered down the prescient execution too; but the potential to make forecasts throughout special populaces ought to likewise be considered as strength, sealing outer legitimacy of the picked technique [25]. The final method on this paper failed to consist of function selection as this failed to discover fundamental upgrades in execution over the cross-endorsement framework..

Conclusion

The development of systems and fashions that useful resource in decoding and comprehending the choices being produced via way of means of AI frameworks is a focal point of the growing studies in logical AI (XAI). XAI strategies may be used to make consequences from AI-primarily based totally impartial frameworks logical and discernible, as required via way of means of the European General Data Protection To permit stepped forward advancements associated with its reception and utilization, the sphere of XAI ought to retain to amplify and begin being hired in AI-primarily based totally frameworks in scientific services. We may be stimulated via way of means of the mental fashions to boost closer to describing and supplying reasons for the AI via way of means of consist of an AI as a member of the group. In comparison to different definitions, ours locations extra emphasis at the context wherein AI is used and calls for precise information of the audience, language, and version's motivation.

Recommendations

To enhance the personalization and effectiveness of mental health care, it is crucial to further develop predictive models that can accurately assess individual responses to therapeutic interventions. Continued research in XAI will support better understanding and implementation of Al-driven solutions in mental health treatment.

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