Using Machine Learning Techniques in Sports Medicine to Predict Injuries and Provide Recommendation to Orthopaedic Treatments after Surgery

Mukesh Madanan[1], Anita Venugopal[2], Nitha C.Velayudhan[3]
[1]Lecturer, [2]IT Instructor, [3]Research Scholar,
[1]Department of Computer Science,
[2] IT Foundation,
[3]Department of Computer Science and Engineering,
[1,2]Dhofar University, Salalah, Oman,
[3]Noorul Islam Centre for Higher Education, Tamil Nadu, India
mukesh@du.edu.om[1],anita@du.edu.om[2],nithacvelayudhan@gmail.com[3]

Abstract—The inconvenience caused by injuries to sports professionals have become a major challenge both on and off the fields. Very occasionally, the players are injured during the practice sessions before the match and they end up suffering for long and these injuries also force them to withdraw from the matches and practices. Several applications of costly technologies have been applied to provide cures and well established attention measures for the injuries sustained but very less has been done to predict and thus prevent the occurrence of these injuries to the players. This is essential since once the injuries are predicted and prevented there will be no need to spend so much on curing these injuries. In addition to this, if an injury occurs and the players have to undergo an orthopaedic surgery their recovery has to be taken care off and a speedy recovery treatment plan has to be formulated. The capabilities provided by artificial intelligence algorithms could be exploited in the prediction of injuries and prevention of injuries to sports persons and aid in their recovery after orthopaedic surgery. The proposed methodology uses Machine Learning algorithm-Naive Bayes- that provides the capabilities of predicting sports injuries and administering recovery after orthopaedic surgeries for the players. Accuracy is a problem that faces the orthopaedic treatment where radiologists' analysis is subject to errors. This problem makes it difficult to determine factors about skeletal tissues such as bone where they are unable to determine their actual nature before surgeries.

Keywords— Machine Learning, Naive Bayes algorithm, Sports Medicine, Orthopaedic Surgery, Injury Prediction

I. INTRODUCTION

Injures are a non-integral part of sports and cause negative impression to both the players and sports lovers**.** The injury prediction methods currently undertaken by teams are focusing on detecting certain variables and numbers that could accurately determine the risk factors directing towards the chance of players getting injured. The physical activities performed by the players are the base of all injury concerns. The non-availability of certain physical exercise data may cause a failure in such a traditional prediction method. The introduction of electronic performance tracking system helps in providing data with high fidelity. The data is extracted from the training sessions and the games played by the players. A number of factors lead to the player getting injured but certain underlying factors predispose players to injuries as well. An example of such an underlying factor is non-contact musculoskeletal soft tissue. The understanding of the concept of the musculoskeletal tissue is still having gaps in sports. In addition to this, genetic data may also have an impact on the chances of a player recovery after they are injured. Recovery plans and rehabilitation and injury prevention methods and strategies should be based on a clear understanding and know-how of risk factor etiology. For certain sports like cricket and football the coach along with the physiologists

develop a training schedule to keep in track the work load of players. In sports such as rugby and ice hockey where the risk is high because of physical contacts between players the injury scare rises to a high extent if their workload is increased beyond a level.

The attainment and maintenance of a stable health and performance after sustaining an injury and surgery thereafter depends on numerous internal and external factors of a player. Sports personals are complex systems. Scientists have made systems that are capable of predicting weather and climatic conditions, forecasting political fatalities and stock exchanges and also traffic fatalities to certain extend. All these systems involve the assessment of sophisticated statistics, studies of complex and multiple simulations, time-associated changes and a relatively considerable large sample data pool. Injuries in sports occur due to variety of reasons and many a times the chances of injury due to external factors are ignored. Professional sports and amateur sports injury scare is crucial when it comes to preventing, diagnosing and managing them. External factors such as playing fields are always a predisposition to injury scare and can be recognized as extrinsic while factors such as age, prior injuries are intrinsic.

The process of data collection and storage and its transfer for the purpose of analysing has become a challenge for IT professionals. The result is to design and implement an innovative system that can perform this entire task highlighting the state-of the art and new communication strategies and technologies. The paper initially discusses the current approach to sports injury prediction and orthopaedics and radiologist detection and treatment issues.

II. LITERATURE REVIEW

The sports industries play a significant role in the economy; injury to players can create huge loss to teams since a lot is being spent on the team players annually for their benefits and welfare. Numerous sport analysis tools have been developed to help the coaches and the medical team to monitor the health conditions of players and to improve their game and planning. But a system that takes the current medical condition of the player as input has to be designed and developed to predict and prevent the risks of injuries happening during training and game sessions to the players. Injuries contribute to the reason why players are unavailable for training and professional games. According to [4], when star players are injured, the quality of a game without their presence is affected, and this may reduce the crowd and number of people watching a match. Therefore, injury management is critical to the success of a player and the team in general.

Artificial intelligence (AI) and its sub field Machine learning (ML) has been applied in the medical fields where the approach is helping out a great extend to deal with the health hazards. ML has proved to be effective in the health care facilities where they are used to process the data collected about a disease or disorder such as the signs and symptoms where the outcomes of the process are the possibilities of the future severity of the disease [6]. In some health care facilities, the technique has been used to compile the data collected after the patients have undergone surgeries and predict the appropriate measures to be done so that the recovery of the patient is enhanced. In such institutions, ML algorithms were useful to determine the nature of the injury and assess the impacts of the disorder so that they provide important information guiding the doctors and surgeons on how to accomplish treatments.

Recently the sports sector has utilized Artificial intelligence in numerous areas such as computer visions, automated journalism, wearable tech and chatbots. In sports, using artificial intelligence chat bots are created to answer fan enquiries regarding any game information, player and game statistics and game arena locations. Car racing uses deep learning neural networks to attain high accuracy in the detection of high speed cars. A combination of IoT with AI can be used to optimize training and performance by gathering data.

In orthopaedics, the ML has been applied generally to the patients requiring surgeries and medical attentions related to skeletal muscles

disorders and bone problems. The details of the injury parts of patients' undergone orthopaedic surgeries are passed through the machine learning algorithms such that the computations of the patterns recorded are done and used to predict some possible outcome of certain procedures [2]. Medical Imaging with the integration of ML, have been used to analyse the changes that occur to the infected body organs using x-rays where the data collected is compared to the one from the past tests and thus enabling the devices to learn what is to be done. Patient undertaking the orthopaedic surgery and medications have their data about the infections and injuries stored in the databases of the devices installed with the ML algorithms for use whenever the prediction is to be done.

ML has been integrated to come up with the development computational capabilities that happen upon the deployment of the techniques of deep learning in sports health care [11]. The developed approaches are used by the radiologist to improve their accuracy in the administration of the treatment. The machine learning technique is used to detect the issues related to bone injuries and cases of skeletal muscles injuries. Additionally, these algorithms used are widely applicable, such as in the Magnetic Resonance Imaging (MRI) where the devices have added computation capabilities which improve their speeds. Incorporation of the ML algorithms in the devices such as MRI improve their speeds and makes them reliable in the predictive processes for some commonly occurring events as the machines can determine the outcomes with the highest probability.

The radiologists in sports medical facilities have assistance from the ML approaches to enhance reduction of the errors related to the computation and interpretation of data for treatment. With the accuracy of above 95%, algorithms in ML have been used to determine the bone ages and interpret the data required for treatment by radiologists. Following an analysis of the situation by the radiologist, the data is then fed into ML algorithms to get another set of prediction. These are then combined to get more sensible and accurate data for treatment. After the determination of the bone ages by the radiologists, the information is used to propose measures and medical responses that are used to ensure that the speedy recovery [8]. ML information collected by the radiologist is also used for the determination of the correct administration of the treatment measures such as for after orthopaedic surgeries. Since the ML algorithms performs better and faster than the radiologist surgeons, medical errors and erroneous medication is avoided by the medical practitioners in many departments of the health care facilities.

Image accuracy has been an issue that lowers the quality of the MRI and other devices that use the images in the diagnosis of the injuries in the body. However, use of the ML technology helps in enhancing the quality of the images where the algorithms allow room for the segregation of the data collected and also create ease of specialization [7]. Clinical injury prediction is a challenge in the field of sports health care. However, ML algorithms have proved to eliminate the speculation and could be employed to provide a more accurate way of predicting outcomes. ML uses risk analysis methods, genomic data and medical images to predict the next phases of injury and the time spans expected for the beginning of the important change in the states of the injuries.

III. PROPOSED METHODOLOGY

The first proposed approach towards the application of the machine learning techniques for injury predictions in the sports medicine and treatment of the orthopaedic issues is the training of the machine learning algorithms. The essence of the training is to ensure that the algorithms to be used can process recurring events and create important information that is helpful in the diagnosis and treatment of the complications. The process also involves the creation of the databases for the records used by the algorithms so that the retrieval and processing of data is done more effectively while the data is organized properly for quick access.

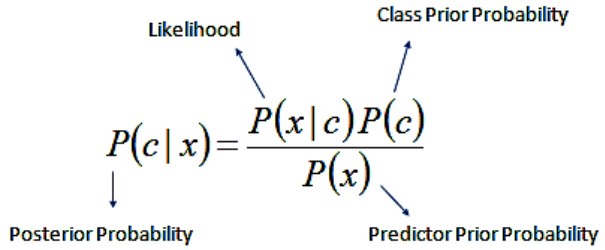
The sports medicine and medical professionals have been faced with the problems of the injuries of players. Some of the methods that are

currently in use are inefficient and less accurate in the prediction and control of the orthopaedic treatments as well. Therefore, there is a need to come up with a model that is reliable in the prediction of the injuries and one that can provide detailed accurate information in orthopaedic treatment. Before the operations of the models, empirical and qualitative approaches are to be taken to ensure that the learning resources for the machine learning algorithms are readily available. In our methodology, the sport medical centres where diagnosis and management of the injuries are done should contain some important predictive tools for injuries like the Naive Bayes model (NB). The model operates by making use of the patient's medical health records and other important data like MRI and X-rays to take as input.

The model can be used by the sports medical response facilities and could include the use of the devices that supports the user input into the system such as voice data, volumetric data and images (from X-rays and MRI) that shows the part where they suspect the injury is likely to occur. With the help of the specific algorithms in the NB model, the medical practitioners can upload the images and volumetric data into the devices where the computation and comparison of the data input can be done[5]. The NB model helps in the analysis and translation of the raw data by the user into the machine language, where it enables the machine to predict the nature of the injury with up to 98% accuracy.

To gain more accuracy and reliability, the NB systems establish more complex data interpretation where the use of multiple layers is used. Complex data interpretation can be achieved via the use of deep learning techniques. Deep learning is influenced by the availability of data in contemporary society and the needs to achieve high computational capabilities. Deep learning is important in the handling of complicated concepts that could be witnessed in the injury of the players where large quantities and special attention could be required for some situations. Neural networks are very useful in the NB model where they run the processes of computing the record pattern recognition to enhance the predictability of the system. However, the advancement of technology makes the evolution of Neural Networks for more sophistication and higher computation capacities.

The NB model works through linear classification that uses Bayes theorem to analyse the future possibilities with an assumption of the future independence. With the use of the Bayesian networks, the medical practitioners in the sports departments are able to input data and establish helpful relationships between the variable that are dependent and independent such as age. The model also makes use of a Bayesian Classifier which is an algorithm that learns to predict the injury occurrence time and types among many other factors related to the injuries for the players. The classifier learns from training data through computing the conditional probabilities. When determining the future outcome of an injury, the NB model assumes the independence of the features. It then uses the Bayes rule to compute the probability of an instance which helps in identifying outcome with the highest posterior.



$$P(c \mid X) = P(x_1 \mid c) \times P(x_2 \mid c) \times \cdots \times P(x_n \mid c) \times P(c)$$

Fig1: NB Classifier

The P(c|x) gives the probability of event c will occur provided event x has already occurred. Here in our case the probability will be injury to sportsperson. Consider an example:

When P(Injury) means how often there is fire, and P(Surgery) means how often we see smoke, then:

P(Surgery|Injury) means how often we see surgery when there is injury.

P(Injury|Surgery) means how often there is injury when we see surgery.
If dangerous surgeries are rare (1%) but injury is fairly common (10%) due to workload, and 90% of dangerous fires make smoke then:

P(Surgery|Injury) =P(Surgery) P(Injury|Surgery) =1% x 90% = 9%P(Injury)10%

In this case 9% of the times expect injury to mean a critical surgery.

Electronic Medical Record (EMR) for the players is essential since they are used to create the profiles of the players and could be used to develop very useful data for the ML algorithms after careful analysis of the same [9]. Additionally, the development of the ML to have the capabilities of handling the data by patients is essential, effective, reliable and cheaper. The ML concepts could be used in the sport medicine to standardize the storage of the players' data using the programs designed for data storage such as Quotient Health. The use of EMR is not only insecure but also less effective in the computation of the data during the processing stages of data. EMR is used widely, but they are ineffective when it comes to the delivery of unique capabilities. Their replacement with the Quotient Health is vital since it provides better service delivery due to the ability to predict and compute large volumes of data in ML.

the predictive machines. The X-rays, MRI and their respective profiles will be collected for the assessment by the machines. Using the data sets provided, the Naive Bayes model will assume the independence of the data input and use the Bayesian theorem and rule to determine the outcome with the highest posterior. However, this will happen after the machine learns about the possibilities which will be accomplished through the use of the training data for the machines. With the help of the classifiers, the output of the process will be processed containing the data like the possible type of injury that the player is likely to suffer after some period of time.

Application of the ML models will help the orthopaedic surgeon to prevent the injuries and provide the recovery plans for the players with the bones and skeletal muscle injuries. After the use of the NB model with the ML algorithms to detect the errors, assessment of the risks of injuries will enables the orthopaedics to advise the players on the protective measures to prevent the occurrence of the risk [10]. Players and patients with the problems that build up slowly within the body will visit the medical support centres for the assessment of the conditions that they experience. Regarding the records of the signs displayed by the current patients, the ML algorithms will estimate the time of injury and the conditions in which one will suffer the injury. This will contribute to either the

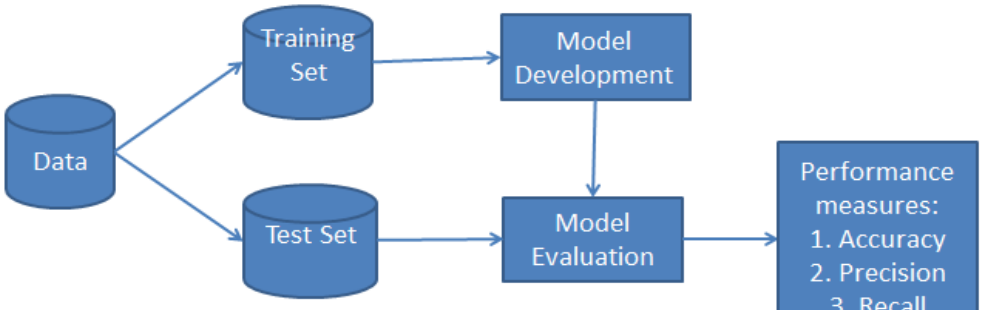


Fig2: NB Workflow

Sports medical centres can apply the model where the players will undergo the diagnosis cycles to collect the important pieces of data to be fed into

recovery from the injury or preventions from occurrence and suffering from the expected injury.

The NB model will require the users to supply a range of qualitative data that will be assessed against various variables to draw conclusions and come up with vital predictions **(1)**. Some of the important data that is useful in the application of the NB model in sports include the informative behaviour of the system. The decisions will be made by the learning system on the extents of the injuries and the treatment procedure to be followed for recovery. Computation of the volumetric data and the images from the MRI and X-rays will be used for computing the output such

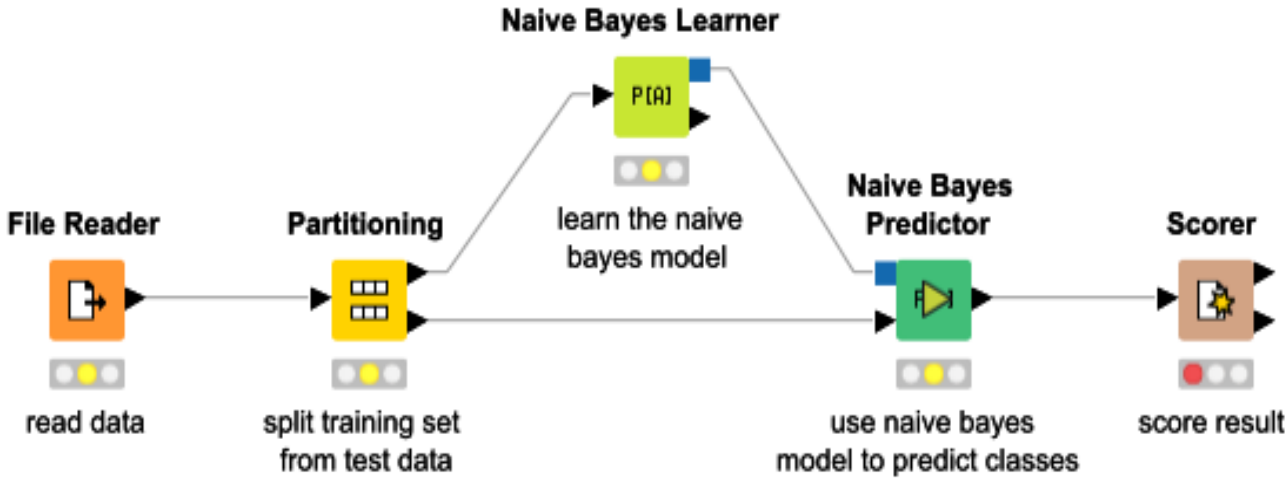


Fig. 3 Proposed Design of the NB Model

images retrieved from the MRI and X-rays. Assessment and prediction of injuries by the NB devices compute these data input and create correlations while determining statistical probabilities and produces desirable outputs [3]. Efficiency and accuracy of the data are ensured where the various machines like MRI are strengthened by the use of the ML algorithms to ensure fast data interpretation and collection. Injury detection is also vital as it enhances the quick response to the risks factors noted and response measures are applied in time so that the players can stay fit.

The learning system will interpret the data that happens occasionally and create decisions based on the statistical probability that will be computed. The machine will output the result of a player's state of injury where the result will include the injury type, severity and time taken for recovery. The previously collected data about the causes of injuries for the other players will be used to populate the patterns and therefore creating as one displaying the positions where the learning systems will detect injuries.

While using the NB models for prediction of the injuries in sportspeople, the input parameters will vary based on the nature and type of injury suspected. The patients will take several tests that will include the collection of the radio logistic data, MRI and X-rays. Then after this data is collected, the learning system will be fed with these data so that they make the decisions by predicting the nature of injuries. Having high computation capabilities, the machine will produce accurate data that will be used for guiding the orthopaedic surgeons on the appropriate measures to take. ML will also require the use of the recurrent data so that it improves its capabilities which grow with time and quantities of data feed to it. Comparison of the current data with the ones that have been processed previously will be very reliable when applying ML in sports medicine.

For the purpose of research, we selected a set of data which will be analysed. The data include factors such as type of injury, Cause of injury,

nature of injury, which body part is injured etc. The data set is then classified and divided into training data set and test data set. This is done for predictive modelling and to have a similarity of the models used for training and testing. Re-sampling methods are used for section of data point's assignment. Depending on the data sets, we will be classifying the severity of injury caused.

IV. RESULTS

The data set was analysed and split into training data set and test data set. For each training and rest data set data points were assigned using stratified re-sampling. To evaluate the performance of the model both the training and test data sets were compared. Initially the injuries were classified to severe and non-severe using Naïve Bayes model by comparing the actual to the predicted ones and results recorded. In comparison to other types of injuries, the permanent partial disabilities had a higher probability that might cause severity to a certain extend. In addition to this, part of injury where injury occurred and the cause of injury were given prior importance. These injuries showed high predictively and more accurate classification and hence had to be dealt with safety analytics. The model aids in classifying injuries and assists medical practitioners to recognise the connection between such injuries and also plan to remove and eliminate such injury causes. Another factor which the model assists is in prioritising the injuries and prevents circumstances which can lead to severe injuries in sportsperson. In case an injury occurs then we can easily suggest an orthopaedic surgery and also calculate the recovery time based on the classification done.

V. CONCLUSION

Numerous studies and research have been conducted on the machine learning models to determine and classify the injuries that can occur to people at workplace or on a sports field. The research focused on additional points such as demography and injury severances.

The problems of high cost incurred for the treatment of the sports injuries will be solved as the players whose injuries will be predicted will be less exposed to the complications. The ML algorithms that will provide the players with details about the expected injuries will provide instructions and vital information about the factors that are exposing the players to injuries where they will be advised to seek alternative or shun away from the activities that predisposes them to injuries. When these measures are taken, the players will be safe from injuries than before where the cost of treatment for injuries will be avoided. Additionally, the time spent on injuries by the player will be greatly reduced as the players will no longer withdraw from the matches and practice sessions due to injuries since they will be prevented. The problems of inaccuracy will be lowered and thus, more successful administration of the treatment will be enhanced with the use of the ML models like Naive Bayes in orthopaedics. The radiologist will incorporate the ML model in the assessment of the bones and skeletal structure, where the algorithms provides more accurate information which will be complimented by the radiologists' findings to arrive at better conclusions. ML models deployed will make certain that the output for the orthopaedic activities enlightens the radiologists on the nature of the bones such as positions, fractures and ages so that the treatment will done with prior information. Risk will be significantly reduced in the field since the information is obtained prior to medical interventions ensures better health care.

Previously, ML models have been used for the production of accurate data that is useful for the doctors to aiding their works. ML has been used for the production of the predictive stats that are used for providing advice for the patients on preventive measures to avoid severe injuries. ML can be applied in the sports where the system models such as NB can be used for the prediction of the injuries type extents and other facts about an injury. Additionally, the capability of the ML can be used for detection of the injuries easily where they are very accurate in analysing data and providing decisions that are useful for the orthopaedic surgeons.

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