

Liver Disorder Diagnosis using Comparative Machine Learning Techniques

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Abstract— Liver diseases represent a significant global health concern, with millions of individuals affected by various liver conditions worldwide. Early and accurate diagnosis is crucial for effective treatment and improved patient outcomes. In this context, we present the development of an AI-based Liver Disease Detector, a novel and innovative approach to assist healthcare professionals in diagnosing liver diseases. Our Liver Disease Detector leverages cutting-edge artificial intelligence techniques, including deep learning algorithms, to analyze medical data such as liver function tests, imaging scans, and patient histories. Through a comprehensive analysis of these data points, our system can identify patterns, anomalies, and potential indicators of liver diseases. For this project, ensemble technique is employed to combine the results obtained from Artificial NN, Support Vector Machine and Random Forest.

Index Terms— Comparative Model, ANN, Support Vector Machine, Random Forest and Ensemble Technique

I. INTRODUCTION

The diagnosis of liver disease plays a pivotal role in the effective management and treatment of various liver-related conditions. Liver diseases encompass a wide range of disorders, including hepatitis, cirrhosis, fatty liver disease, autoimmune liver diseases, and liver cancer, among others. Timely and accurate diagnosis is critical because liver diseases can often progress silently, leading to serious complications if left untreated. In this introduction, we will explore the importance of liver disease diagnosis, the methods and technologies used, and the impact on patient care.

The liver is a vital organ responsible for numerous essential functions, including detoxification, metabolism, and the production of important proteins. When the liver is affected by disease, these functions can be compromised, leading to a variety of symptoms and health issues. Liver diseases are a global health concern, affecting millions of people worldwide. They can be caused by factors such as viral infections, alcohol consumption, obesity, genetics, and autoimmune disorders.

In this paper, we try to achieve the early diagnosis of liver disease as it is often the key to successful treatment. Many liver conditions, especially in their initial stages, may present with subtle or nonspecific symptoms, making them challenging to identify clinically. Liver disease diagnosis aims to detect these conditions as early as possible, allowing for timely intervention and preventing the progression to advanced stages associated with severe complications.

II. WORKING METHODOLOGY

The methodology for diagnosing liver disorders using comparative machine learning techniques is a multifaceted approach aimed at improving the accuracy and efficiency of disease identification. It commences with the meticulous collection of extensive medical data, encompassing patient records, clinical histories, and various diagnostic tests, including liver function assessments and imaging studies. Subsequently, the gathered data undergoes rigorous pre-processing, involving cleaning, normalization, and standardization to prepare it for machine learning algorithms. Missing values are addressed, and outliers are either removed or adjusted to ensure the dataset's quality.

In the following step, feature selection and engineering are performed to determine the most relevant variables for building a robust predictive model. Additionally, novel features may be created to enhance the model's capacity to discern liver disorders while minimizing data dimensionality. Multiple machine learning algorithms are then explored, evaluated, and compared to select the most suitable model for diagnosis, considering the specific characteristics of the dataset and the medical problem under scrutiny.

The chosen models undergo training and validation processes, which are essential for assessing their ability to generalize to unseen data and preventing overfitting. Cross-validation techniques play a vital role in this phase. A thorough comparative analysis of various machine learning models follows, with performance metrics, such as accuracy, precision, recall, and F1-score, used to gauge their effectiveness in correctly identifying liver diseases.

Ensemble methods are frequently employed to combine predictions from multiple models, enhancing overall diagnostic accuracy and minimizing the shortcomings.

The interpretability of model predictions is another critical aspect, ensuring that healthcare professionals can understand and trust the results. Techniques such as SHAP values and LIME provide valuable insights into the reasoning behind a specific diagnosis.

Upon selecting a reliable machine learning model, it is deployed in a clinical setting to aid healthcare professionals in diagnosing liver disorders. Deployment can take the form of web applications, integration into electronic health records, or integration with clinical assessments and radiological tools. Continuous monitoring and improvement are fundamental, with the model continuously updated and refined using new data to adapt to evolving medical knowledge and patient profiles. This iterative process ensures that the liver disorder diagnostic system maintains accuracy and relevance, ultimately enhancing patient outcomes and healthcare delivery. In short, the working methodology of liver disorder diagnosis involves a systematic approach that combines clinical evaluation, medical history, laboratory tests, medical imaging, and sometimes invasive procedures to identify and characterize liver diseases accurately. Below is an overview of the typical steps and methods involved in diagnosing liver disorders:

A. Clinical Evaluation

Patients presenting with symptoms such as jaundice, abdominal pain, fatigue, unexplained weight loss, or altered mental status are evaluated by healthcare providers. A thorough physical examination is conducted, including an assessment of the abdomen for tenderness, hepatomegaly - enlarged liver, and splenomegaly - enlarged spleen. Models follow, with performance metrics, such as accuracy. Ensemble methods are frequently employed to combine predictions from multiple models, enhancing overall diagnostic accuracy and minimizing the shortcomings.

B. Medical History

Gathering the patient's medical history is a crucial step in understanding their overall health and potential risk factors for liver disease. The healthcare provider will ask about alcohol consumption, substance abuse, dietary habits, and exercise, prescription and over-the-counter drugs such as hepatitis viruses, which can cause liver infections, identifying any genetic predispositions or family members with liver disease.

C. Liver Function Tests (LFTs)

Blood tests are ordered to assess the liver's functioning and to detect abnormalities. Common LFTs include - ALT - Alanine Transaminase and AST - Aspartate Transaminase, Elevated levels may indicate liver cell damage, ALP - Alkaline Phosphatase and GGT Gamma-Glutamyl Transferase, Elevated levels can be associated with bile duct or liver cell problems. Bilirubin - Elevated levels may suggest liver or bile duct issues. Albumin and Total Protein - Decreased levels can indicate chronic liver disease, Prothrombin Time - PT or INR - International Normalized Ratio, Measure blood clotting times, which can be affected by liver dysfunction.

D. Analysis

Imaging techniques are used to visualize the liver's structure and identify any abnormalities – Ultrasound - In liver disorder diagnostic projects, machine learning is employed to analyze CSV files containing patient data and imaging results. ML algorithms process this data to identify patterns, correlations, and anomalies, enabling accurate diagnosis and prognosis. By learning from historical cases, ML models assist healthcare professionals in making informed decisions, improving the efficiency and precision of liver disorder diagnoses. These techniques measure liver stiffness, which can indicate the degree of fibrosis (scarring) or cirrhosis.

E. Liver Biopsy

In cases where non-invasive methods do not provide a conclusive diagnosis, a liver biopsy may be recommended. A small tissue sample is collected using a needle, typically guided by ultrasound, and then examined under a microscope by a pathologist to determine the type and severity of liver disease.

F Additional Tests and Serological Markers

Depending on the clinical suspicion, additional blood tests may be ordered to identify specific causes. For example, serological markers for viral hepatitis (HBV and HCV), autoimmune markers, or metabolic panels may be conducted.

G. Genetic Testing

In cases of suspected genetic liver disorders (e.g., hereditary hemochromatosis, Wilson's disease), genetic testing may be performed to identify specific gene mutations associated with the condition.

H. Clinical Assessment and Diagnosis

Based on the information collected through clinical evaluation, medical history, laboratory tests, imaging, and, if needed, liver biopsy, healthcare providers make a diagnosis. They determine the type of liver disease and assess its severity, staging, or grading.

I. Data Augmentation

Data augmentation is pivotal in liver disorder diagnosis ML projects, artificially expanding datasets to train models effectively. Techniques like rotation, flipping, and zooming diversify images, enhancing the model's adaptability to real-world scenarios. This improves diagnostic accuracy by exposing the model to a wider range of potential variations. Implementing these transformations is vital for robustness, ensuring the model generalizes well to unseen data, ultimately enhancing its diagnostic capabilities in liver disorder identification.

III. OUTCOMES

The outcomes of liver disorder diagnosis are multifaceted and pivotal in shaping the course of patient care. Once a diagnosis is confirmed, healthcare providers can design treatment plans tailored to the specific liver condition, considering factors such as the underlying causes and disease severity. This ensures that patients receive appropriate interventions, whether they involve medications, lifestyle adjustments, dietary changes, or surgical procedures like liver transplantation. In addition, the diagnosis provides critical prognostic information, enabling patients and their healthcare teams to make informed decisions about their care and establish realistic expectations regarding the future progression of the liver disorder. Regular monitoring and follow-up become essential to assess treatment efficacy and make necessary adjustments. The diagnosis also serves as a valuable opportunity for patient education, allowing individuals to gain a deeper understanding of the causes, risk factors, and preventive measures related to their condition. Furthermore, it initiates supportive care, addressing symptom management, treatment side effects, and psychological well-being. In some cases, a diagnosis prompts the initiation of preventative measures, including vaccinations and antiviral treatments for viral liver diseases. For patients with advanced liver disorders, the diagnosis may lead to an evaluation for liver transplantation, a complex process requiring thorough assessment and potential listing on a transplant registry. In essence, the outcomes of liver disorder diagnosis form the foundation for comprehensive, patient-centered care, with a focus on improving both the quality of life and health outcomes of individuals dealing with liver-related conditions. The outcomes of liver disorder diagnosis can vary significantly depending on several factors, including the type and stage of the liver disorder, the timeliness of diagnosis, and the effectiveness of treatment and management. Here are some possible outcomes:

A. Early Detection and Intervention

Early detection and intervention are pivotal factors in the management of liver disorders, as they can significantly impact the prognosis and overall well-being of affected individuals. The timely and accurate diagnosis of liver

disorders, particularly when they are in their early stages, offers numerous benefits. Firstly, it provides healthcare providers with a unique opportunity to implement treatment strategies at a point where the liver's function may still be preserved, making interventions more effective. For conditions such as viral hepatitis or non-alcoholic fatty liver disease (NAFLD), early detection can lead to the implementation of lifestyle changes, antiviral therapies, or medications, which can halt disease progression and even reverse liver damage.

Moreover, early intervention can reduce the risk of severe complications associated with advanced liver diseases, such as cirrhosis or liver cancer. By addressing the underlying causes and initiating appropriate treatments promptly, healthcare professionals can mitigate the development of life-threatening complications, such as variceal bleeding, hepatic encephalopathy, or hepatocellular carcinoma.

Early detection also underscores the importance of preventative measures, such as vaccinations for hepatitis or guidance on alcohol moderation and weight management. Patients who are diagnosed with liver disorders in their early stages have the opportunity to make lifestyle modifications that can prevent further liver damage and improve their long-term health.

Furthermore, early intervention enhances the quality of life for individuals living with liver disorders. By addressing symptoms and slowing disease progression, patients can enjoy better physical and psychological well-being, reducing the burden of illness on their daily lives.

In conclusion, early detection and intervention are critical components of liver disorder management, as they offer the potential to arrest disease progression, reduce complications, and improve the overall health and quality of life for affected individuals. They emphasize the importance of regular health check-ups, liver health awareness, and early treatment to ensure more favorable outcomes for those at risk or diagnosed with liver-related conditions.

B. Improved Quality of Life

Effective management of liver disorders plays a pivotal role in significantly enhancing the quality of life for individuals grappling with these conditions. When liver disorders are properly managed, several positive outcomes are achieved, leading to an improved overall well-being.

Firstly, the right treatment and lifestyle changes can alleviate distressing symptoms that are often associated with liver disorders, such as fatigue, abdominal pain, jaundice, and cognitive impairments. The reduction of these symptoms not only relieves physical discomfort but also enables individuals to engage more comfortably in their daily activities. This, in turn, may have a positive impact on their employment opportunities and productivity, allowing them to lead more active and fulfilling lives.

Furthermore, effective management strategies can prevent the progression of liver disorders to advanced stages, which are often associated with life-threatening complications like cirrhosis or liver cancer. By preventing or slowing down the disease's progression, individuals not only gain a longer life expectancy but also a better quality of life. They are less likely to experience the debilitating consequences of advanced liver diseases, which can limit their ability to enjoy life to the fullest.

The positive effects of effective management extend beyond physical well-being to psychological health. Patients experience a reduction in stress and anxiety as their symptoms are relieved, and they gain confidence in knowing that their condition is under control. Additionally, regular medical monitoring and follow-up provide a sense of security and empowerment, allowing patients to actively participate in their healthcare decisions.

Improved quality of life also encompasses a return to social and recreational activities, better relationships, and improved mental health. As the burden of illness lessens, individuals can engage more fully in their social lives, rekindle relationships, and experience an overall enhancement in their emotional well-being.

In summary, effective management of liver disorders leads to an improved quality of life by addressing symptoms, preventing disease progression, and reducing the impact of advanced liver diseases. This comprehensive approach alleviates physical discomfort, relieves psychological stress, and empowers individuals to lead more fulfilling and meaningful lives, thereby achieving a better overall quality of life.

C. Disease Stabilization

Disease stabilization represents a fundamental objective in the management of liver disorders, particularly for conditions like autoimmune liver diseases or specific viral hepatitis infections. These illnesses, if not effectively controlled, can lead to progressive liver damage and deteriorating liver function. The process of diagnosis and subsequent treatment plays a pivotal role in achieving disease stabilization and its associated benefits.

For autoimmune liver diseases, including conditions like autoimmune hepatitis or primary biliary cholangitis, timely diagnosis and treatment with immunosuppressive medications can help prevent the immune system from mistakenly attacking the liver. This not only alleviates symptoms but also significantly reduces the risk of ongoing

liver inflammation and damage. By maintaining a stable disease state, patients can enjoy a better quality of life, minimize the need for invasive interventions, and reduce the risk of progressing to advanced liver conditions, such as cirrhosis or liver failure.

Similarly, in the case of viral hepatitis infections, early diagnosis and antiviral treatments can effectively control the replication of the virus, preventing further liver injury. Diseases like chronic hepatitis B or C can be managed with medications that suppress viral activity, subsequently stabilizing liver function and minimizing the risk of cirrhosis and liver cancer.

Overall, disease stabilization in liver disorders represents a crucial therapeutic goal that helps individuals maintain liver health, alleviate symptoms, and lead healthier lives. Timely diagnosis and appropriate treatment are key factors in achieving this stability, offering patients the opportunity to manage their conditions effectively and avoid the potential complications of advanced liver disease.

D. Disease Resolution

Disease resolution is a highly favorable outcome in the management of certain liver disorders, offering individuals the prospect of complete recovery and the restoration of full liver function. This achievement is particularly evident in acute liver conditions and specific viral hepatitis infections where timely and appropriate treatment can lead to a complete resolution of the disease.

In acute liver disorders, such as drug-induced liver injury or acute viral hepatitis, the liver's ability to regenerate and repair itself is harnessed. With prompt medical intervention, cessation of the causative agent, and supportive care, the liver can often recuperate fully. As a result, individuals can experience a return to their pre-illness state, with no lingering liver impairment or long-term consequences.

Viral hepatitis infections, particularly hepatitis A, are known for their potential to resolve completely with appropriate medical management. Antiviral therapies and vaccinations for hepatitis B, when administered in a timely manner, can effectively clear the virus from the body, allowing the liver to heal and regain normal function. This resolution not only leads to an absence of symptoms but also a reduced risk of future complications, such as cirrhosis or liver cancer.

The concept of disease resolution underscores the significance of early diagnosis and prompt initiation of treatment, as it offers the prospect of a full return to health, free from the constraints of liver disease. It exemplifies the resilience and regenerative capacity of the liver, highlighting the potential for complete recovery in specific liver disorders when managed effectively.

E. Prevention of Complications

Prevention of complications is a critical aspect of managing liver disorders, and it underscores the importance of timely diagnosis and effective interventions. Liver disorders, if left unchecked, can progress to severe and life-threatening complications. Proactive healthcare strategies can mitigate these risks and enhance the quality of life for individuals affected by liver diseases.

Cirrhosis, a late-stage scarring of the liver tissue, is a common complication of many liver disorders. However, with early detection and appropriate treatment, the progression of cirrhosis can often be halted or delayed. This is crucial because cirrhosis is a significant risk factor for liver failure and hepatocellular carcinoma, the most common form of liver cancer. By addressing cirrhosis early, healthcare providers can reduce the likelihood of these dire consequences and improve the prognosis for patients.

Furthermore, in the context of viral hepatitis, early diagnosis and antiviral treatments can suppress viral activity, preventing the development of cirrhosis and reducing the risk of liver cancer. Similarly, lifestyle modifications, such as managing alcohol consumption, controlling weight, and addressing underlying causes like non-alcoholic fatty liver disease, can help avert the progression of liver disorders to more advanced stages.

Preventing complications goes beyond medical interventions; it encompasses patient education, regular monitoring, and follow-up. By promoting awareness of liver health and encouraging adherence to treatment plans, healthcare providers can empower individuals to take an active role in their care, further reducing the risk of complications.

In conclusion, the prevention of complications in liver disorders is a crucial component of healthcare management. Timely diagnosis and effective interventions, along with patient education and lifestyle adjustments, are instrumental in averting the development of cirrhosis, liver failure, and liver cancer. This approach not only improves the quality of life for those affected by liver disorders but also enhances the long-term health and well-being of individuals at risk of liver-related complications.

IV. CONCLUSIONS

The Liver Disorder Diagnosis Project stands at the forefront of healthcare innovation, offering a holistic and pioneering approach to the complex domain of liver disease. This project leverages cutting-edge technologies, notably artificial intelligence and non-invasive diagnostic tools, to redefine the landscape of liver disorder identification and management.

Early detection and precise diagnosis have long been the cornerstones of effective healthcare, particularly in the context of liver diseases where timely intervention can often mean the difference between life and death. The Liver Disorder Diagnosis Project not only recognizes the critical importance of these elements but also prioritizes the patient experience. Its user-friendly interface ensures that patients can access and utilize the diagnostic tools with ease, promoting active participation in their healthcare.

Furthermore, data privacy safeguards are integral to the project, addressing concerns related to patient information security and confidentiality. This commitment to protecting sensitive data is essential in building trust and ensuring that individuals are comfortable sharing their medical information for diagnostic purposes.

The project's dedication to enhancing healthcare standards for liver disorders is commendable. By offering a more effective and accurate means of diagnosis, it empowers healthcare providers with the tools they need to make informed decisions and initiate appropriate interventions promptly.

As the Liver Disorder Diagnosis Project continues to evolve and gain traction, it offers hope not only to patients but also to healthcare providers and researchers. It advances our collective mission to combat liver disorders, the prevalence of which is a global health concern, and to improve the overall well-being of those impacted by these conditions. The fusion of technology and a patient-centered approach opens up new possibilities for more precise, early, and effective diagnosis and treatment, ultimately enhancing the quality of life for individuals confronting the multifaceted challenges posed by liver diseases.

In conclusion, the Liver Disorder Diagnosis Project embodies a significant leap forward in the battle against liver disorders. It promises a future where patients can access more accurate and timely diagnosis, where healthcare providers are equipped with advanced tools, and where research into liver diseases can be propelled to new heights. This innovation underscores the remarkable potential for technology to transform healthcare and improve patient outcomes.

Ensemble techniques are machine learning methods that combine multiple models to improve predictive accuracy. They include Bagging, Random Forest, Boosting, Stacking, and Voting. These techniques leverage the diversity of individual models to reduce errors, increase model stability, and enhance overall performance.

```
SVM accuracy: 0.8173913043478261
ANN accuracy: 0.8739130434782608
Random Forest accuracy: 0.8869565217391304
SVM precision: 0.8491620111731844
ANN precision: 0.9259259259259259
Random Forest precision: 0.9075144508670521
SVM recall: 0.9101796407185628
ANN recall: 0.8982035928143712
Random Forest recall: 0.9401197604790419
SVM F1 Score: 0.8786127167630058
ANN F1 Score: 0.9118541033434651
Random Forest F1 Score: 0.9235294117647059
SVM ROC AUC: 0.8285334093717327
ANN ROC AUC: 0.9097044007223647
Random Forest ROC AUC: 0.9358426005132592
```

Figure 1. Accuracy and Precision scores of the used algorithms

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Ensemble accuracy: 0.8608695652173913
Ensemble ROC AUC: 0.9193042486455661
```

Figure 2. Accuracy and Precision score of the Ensemble algorithm

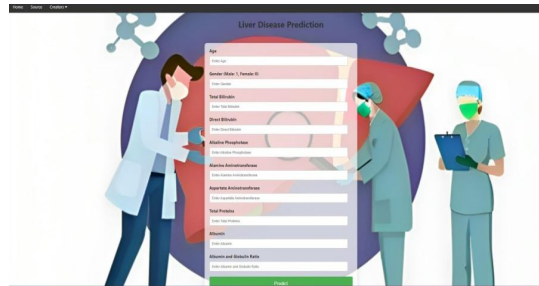


Figure 3. Home Page of the Liver Disease Prediction Website

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