Project Design Phase-II

Solution Requirements (Functional & Non-functional)

Date: 28 June 2025
Team ID: LTVIP2025TMID45560
Project Name: Revolutionizing Liver Care: Predicting Liver Cirrhosis using Advanced Machine Learning Techniques
Maximum Marks: 4 Marks

Functional Requirements:

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Clinical Data Input Management	Input clinical parameters via web form Data validation and range checking Support for multiple data formats Save and retrieve patient data
FR-2	Machine Learning Prediction Engine	Load trained ML models (XGBoost, Random Forest) Process clinical features for prediction Generate cirrhosis risk assessment Provide prediction confidence scores
FR-3	User Authentication & Access Control	Healthcare professional login system Role-based access control (Doctor, Technician) Patient consent management Session management and timeout
FR-4	Results Management & Reporting	Display prediction results with visualization Generate detailed medical reports Export results in PDF/Excel format Historical prediction tracking
FR-5	Data Preprocessing & Validation	Handle missing values in clinical data Normalize and scale input features Validate data integrity and consistency Error handling for invalid inputs
FR-6	Model Management & Updates	Load different ML models dynamically Model version control and rollback Performance monitoring and logging Model retraining capabilities
FR-7	Dashboard & Analytics	Healthcare provider dashboard Patient risk analytics and trends Statistical summaries and insights Real-time system health monitoring
FR-8	Integration & Interoperability	Integration with Hospital Information Systems HL7 FHIR standard compliance API endpoints for external systems Electronic Health Record (EHR) integration

---

Non-functional Requirements:

Following are the non-functional requirements of the proposed solution.

NFR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	**User Interface:** Intuitive and user-friendly web interface with minimal learning curve for healthcare professionals **Accessibility:** WCAG 2.1 AA compliance for users with disabilities **Responsive Design:** Compatible across desktop, tablet, and mobile devices **Error Handling:** Clear error messages and guidance for corrective actions **Help System:** Comprehensive help documentation and tooltips
NFR-2	**Security**	**Data Encryption:** End-to-end encryption for patient data (AES-256) **Authentication:** Multi-factor authentication for healthcare providers **Authorization:** Role-based access control with least privilege principle **HIPAA Compliance:** Full compliance with healthcare data protection regulations **Audit Logging:** Complete audit trail for all system activities **Data Anonymization:** Patient data anonymization for research purposes
NFR-3	**Reliability**	**System Uptime:** 99.9% availability during business hours **Fault Tolerance:** Graceful degradation in case of component failures **Data Integrity:** Backup and recovery mechanisms with RPO < 1 hour **Error Recovery:** Automatic recovery from transient failures **Monitoring:** Real-time system health monitoring and alerting
NFR-4	**Performance**	**Response Time:** Prediction results delivered within 3 seconds **Throughput:** Support for 100+ concurrent users **Resource Optimization:** Efficient memory and CPU usage **Model Loading:** ML model loading time < 5 seconds **Database Performance:** Query response time < 1 second for data retrieval
NFR-5	**Availability**	**Business Hours:** 99.9% uptime during 6 AM to 10 PM **Maintenance Windows:** Scheduled maintenance with minimal downtime **Disaster Recovery:** RTO (Recovery Time Objective) < 4 hours **Load Balancing:** Distribute traffic across multiple server instances **Health Checks:** Automated health monitoring with failover capabilities
NFR-6	**Scalability**	**Horizontal Scaling:** Support for adding server instances based on demand **Database Scaling:** Read replicas and database sharding capabilities **Auto-scaling:** Cloud-based auto-scaling based on CPU/memory thresholds **Cache Management:** Redis caching for frequently accessed data **CDN Integration:** Content delivery network for static resources
NFR-7	**Maintainability**	**Code Quality:** Well-documented, modular, and testable codebase **Version Control:** Git-based version control with branching strategy **Deployment:** CI/CD pipeline for automated testing and deployment **Logging:** Comprehensive logging for debugging and troubleshooting **Configuration Management:** Externalized configuration for different environments
NFR-8	**Compliance & Standards**	**Medical Standards:** Compliance with FDA guidelines for medical software **Data Standards:** HL7 FHIR for healthcare data exchange **Quality Standards:** ISO 27001 for information security management **Regulatory Compliance:** GDPR compliance for

NFR No.	Non-Functional Requirement	Description
		European patient data **Clinical Guidelines:** Adherence to liver disease diagnostic guidelines

Detailed Functional Requirements Specifications:

FR-1: Clinical Data Input Management

Priority: High
Description: Enable healthcare professionals to input patient clinical and biochemical data through a secure web interface.

Acceptance Criteria:

- System accepts all required clinical parameters (age, gender, bilirubin, albumin, liver enzymes, etc.)
- Real-time validation ensures data integrity and appropriate ranges
- Support for both manual entry and file upload (CSV/Excel)
- Auto-save functionality to prevent data loss

FR-2: Machine Learning Prediction Engine

Priority: High
Description: Process clinical data through trained ML models to predict liver cirrhosis risk.

Acceptance Criteria:

- XGBoost model achieves ≥90% prediction accuracy
- System provides confidence scores for predictions
- Multiple model comparison capabilities
- Prediction results generated within 3 seconds

FR-3: User Authentication & Access Control

Priority: High
Description: Secure authentication system for healthcare professionals with role-based access.

Acceptance Criteria:

- Multi-factor authentication implementation
- Role-based permissions (Doctor, Technician, Administrator)
- Session timeout after 30 minutes of inactivity
- Password policy enforcement

Quality Attributes Matrix:

Quality Attribute	Measurement Criteria	Target Value	Testing Method
Accuracy	ML Model Prediction Accuracy	≥90%	Cross-validation testing
Response Time	Time from input to prediction	≤3 seconds	Performance testing
Availability	System uptime percentage	99.9%	Monitoring tools
Security	Vulnerability assessment score	Zero critical vulnerabilities	Security testing
Usability	Task completion rate	≥95%	User acceptance testing
Scalability	Concurrent user support	100+ users	Load testing

Constraints and Assumptions:

Technical Constraints:

- Compatible with modern web browsers (Chrome, Firefox, Safari, Edge)
- Minimum Python 3.8+ for backend development
- Database storage capacity planning for patient data growth
- Network bandwidth requirements for real-time predictions

Business Constraints:

- HIPAA compliance mandatory for US healthcare market
- Integration timeline with existing hospital systems
- Budget limitations for cloud infrastructure
- Training requirements for healthcare staff

Assumptions:

- Healthcare professionals have basic computer literacy
- Reliable internet connectivity at healthcare facilities
- Patient consent obtained for data processing
- Clinical data quality maintained by healthcare providers

Risk Mitigation Strategies:

1. **Data Privacy Risk:** Implement comprehensive encryption and access controls
2. **Model Accuracy Risk:** Continuous model validation and retraining
3. **System Downtime Risk:** Redundant infrastructure and failover mechanisms
4. **Integration Risk:** Phased rollout with pilot testing
5. **Compliance Risk:** Regular audits and compliance monitoring