

**Development of Net Enabled Retinal Image Analysis, Screening System for Grading and Diagnosis of Diabetic Retinopathy**

No.	Elapsed time from start (in months) of the project	Milestone	Deliverables	Status
1.	03	<ul style="list-style-type: none"> <li>✓ Collection of datasets using benchmark databases</li> <li>✓ Retinal image preprocessing</li> <li>✓ Extraction of blood vessels, optic disc and macula</li> <li>✓ Designing of easy to use GUI for DR software</li> <li>✓ Designing main layout for database</li> <li>✓ Designing of communication software interface</li> </ul>	<ul style="list-style-type: none"> <li>• Algorithms developed in MATLAB and tested bench-mark databases* for preprocessing and main component extraction</li> <li>• Basic layout of application software</li> <li>• Basic forms for database</li> <li>• A software containing basic layout for communication interfaces</li> </ul>	Submitted
<p>The first step to start the project was to collect different bench mark databases and to extract required information from them to generate different datasets. For this purpose, four main publicly available retinal image databases (DRIVE, STARE, DiaretDB and MESSIDOR) as mentioned in the proposal were used. The descriptions about the databases to generate datasets are gathered at two levels i.e. image and lesion with the help of ophthalmologists. The image level description contains a single description about the complete image that is normal or with DR. It means that if a fundus image contains any type of lesion, it is considered as affected. The affected images are further categorized into three categories which are mild, moderate and severe depending on type and number of lesions present on surface of retina.</p> <p>Front-end application to capture patient information and retinal images at remote site/hospital terminal Database is an important part in the project. In the achievement of this milestone, basic layout of this application is developed. Application requires the operator to login before registering new patient and capturing his/her retinal image. Basic interface is provided to Add/register new patients by entering their information/image</p>				
2.	06	<ul style="list-style-type: none"> <li>✓ Conversion of preprocessing and main component extraction algorithms into high level Language</li> <li>✓ Candidate Lesion extraction using filter banks</li> <li>✓ Feature extraction</li> <li>✓ Data transmission via Universal communication device</li> </ul>	<ul style="list-style-type: none"> <li>• Algorithms developed in high level language for preprocessing and main component extraction</li> <li>• Algorithms developed in MATLAB for candidate lesion extraction and feature set formulation</li> <li>• An interface for data and retinal image transmission via communication device</li> </ul>	Submitted
<p>Development of equivalent implementation of algorithms, developed in MATLAB, for pre-processing and main component extraction is an important step. In the achievement of this milestone, basic image processing routines, available in MATLAB but not exactly available in C#, are implemented. Special attention has been given to achieve consistency in the results obtained using MATLAB and its equivalent implementation in C#. Algorithms</p>				

	<p>for main component extraction go through a process of evolution due to real life scenarios that have been confronted due to the capturing of real-life data from hospital. Their implementation in high language has been updated accordingly.</p> <p>PI has also developed high end implementation of pre-processing steps and main component extraction equivalent to the algorithms developed in MATLAB. These are integrated with front-end application to analyze retinal image based on detected components such as vessels, optic disk, macula etc.</p>			
3.	09	<ul style="list-style-type: none"> <li>✓ Conversion of candidate lesion extraction and feature set formulation algorithms into high level Language</li> <li>✓ Implementation of GMM, SVM and m-Mediods classifiers and their analysis</li> <li>✓ Interfacing the communication software with the database and SAN</li> </ul>	<ul style="list-style-type: none"> <li>• Algorithms developed in high level language for candidate lesion extraction and feature set formulation</li> <li>• Algorithms developed in MATLAB for classification and their results for DR classification tested on Benchmark databases</li> <li>• Communication software along with its interface to database and SAN</li> </ul>	Submitted
<p>Keeping in view the deployment of the software at AFIO MH RWP as early as possible and the inclusion of the preliminary image analysis for the use of automatic diagnosis, especially for obtaining doctors feedback on the accuracy and reliability, it is decided to incorporate algorithms developed in MATLAB as Dot Net C# Assemblies (DLLs) in the software. This helped in a faster and efficient way to include Diabetic Retinopathy NPDR as a working automatic diagnosis in the deployable software package.</p> <p>The algorithms for NPDR lesions (exudate and hemorrhages) are integrated with the software by using MATLAB DLL files. The conversion to C# is still remaining which will be carried out once we have positive feedback from AFIO.</p> <p>PI has completed the SVM and GMM classifiers implementation in MATLAB. Similarly, during this quarter communication team has worked to deploy the system at AFIO. There were necessary changes required by the AFIO ophthalmologists which including updates at the front end and backend. Communication team has updated the database and modified the communication software (web services) to meet the requirements. Currently, a there is a working communication web services integrated with frontend (remote terminal) and backend database based on AFIO requirements. The ophthalmologist can perform all necessary tasks on the system from the remote terminal and system persist all data to the centralized database through communication web services. Some of the main tasks that ophthalmologists can perform are:</p> <ol style="list-style-type: none"> <li>1. Add, update, and delete patients</li> <li>2. Add, update, and delete diagnosis information of patients</li> <li>3. View history of specific patient</li> <li>4. Multi criteria search of patient's data and history</li> <li>5. Acquire a funds image of patient using non mydriatic camera</li> <li>6. Store the image to the centralized server</li> <li>7. Retrieve the image of a specific client</li> </ol> <p>PI has also updated communication software that is integrated with frontend (remote terminal) and backend database. We still need to integrate Storage Area Network to improve the performance of images to store and retrieve.</p>				

4.	12	<ul style="list-style-type: none"> <li>✓ Designing of Hybrid classifier and testing for grading of DR</li> <li>✓ Conversion of classification algorithms into high level Language</li> <li>✓ Development of complete database</li> <li>✓ Interfacing the communication module with the server</li> </ul>	<ul style="list-style-type: none"> <li>• Algorithms developed in high level language for DR classification</li> <li>• Complete software for DR grading</li> <li>• SQL based database</li> <li>• Complete communication software</li> </ul>	Submitted
<p>Algorithms in high language for DR classification have been developed and submitted alongwith the screenshots of software and SQL based database schema. Similarly, the communication software consists of following modules:</p> <p><b>DR grading software (client side):</b> Client application interfaced the fundus camera, acquires patient's eye image and then requests server over network to use the remote functionalities of RIDDWS's server application for storing the records of data. This application requests the RIDDWS application for the above functionalizes over network and provides proper GUI's to the end user at client side, moreover also communicates with the fundus camera for acquiring the eye image.</p> <p><b>RIDDWS (Server side):</b> RIDDWS is a java application running at server side provides all CRUD (Create, Read, Update, and Delete) operations and functionalities to their clients. It exposes their functionalities using web services layer using Axis2 technology and stores the records in the database using an ORM (Object relational model) layer of Hibernates at server side.</p>				
5.	15	<ul style="list-style-type: none"> <li>✓ Integration of software with fundus camera</li> <li>✓ Testing the complete system for real time processing</li> <li>✓ Testing the real time communication and reporting</li> <li>✓ Research paper writing</li> </ul>	<ul style="list-style-type: none"> <li>• Evaluation results for actual patients</li> <li>• Database and patient management system</li> <li>• A complete DR detection, grading and screening software as proposed</li> <li>• International publications</li> </ul>	Pending
6.	16	<ul style="list-style-type: none"> <li>✓ Completion of Field-Prototype with 3 clients and 1 server.</li> </ul>	<ul style="list-style-type: none"> <li>• Prototype System comprised of three clients and one server working at Shifa blood collection centers</li> </ul>	Not Due