# Automatic Document Segmentation of Mobile Captured Medical Examination Forms in a Tele-Diagnosis System

A Thesis Proposal
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by

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**Abstract**

GetBetter, a telemedicine system, utilizes medical forms as means to collect data from patients. This paper discusses a proposed implementation of a suitable segmentation algorithm that will be used to extract fields from a digital photograph of a medical form. Several segmentation methods will be compared to arrive at the best possible implementation. If necessary the medical form is to be modified to enhance the segmentation. The segmentation process includes an implementation of a database system to store the data, an Optical character recognition module to translate the digital images to string and an android tablet application to take the photos of medical forms and communicate with the server.

**Keywords:** telemedecine, segmentation, optical character recognition

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# Chapter 1

# Research Description

## 1.1 Overview of the Current State of Technology

Telediagnosis is a diagnosis that occurs at a remote location and is based on the evaluation of data transmitted from devices that monitor the patient ("Dictionary.com Unabridged", 2016). Computer systems connecting patients, midwives and doctors assist the telediagnosis process. For maximized collaboration and effectiveness, a good system design must adjust to the current business process the doctors and midwives are familiar with and not the other way around. The system must be a convenient tool for the people using it. Since the doctors and midwives are adapted to traditional ways such as writing on paper or vocal narration, it is best if they are not forced to divert from what they are already used to doing.

Replicating the current business process opens numerous computing challenges. One of which involves the management of paper forms. In the medical world, paper forms are used to contain and organize patient data in a uniform way. It is vital to the whole diagnosis process because it contains relevant information regarding the ailment of the patient and mismanagement of such forms can cause misdiagnosis and may endanger the patients life. This study will propose a method to manage such forms in a digital space. It will present ideas relevant to the problem, such as image segmentation, storage, retrieval, structuring and digitalization of paper forms. The study will also describe the process of deciding which method is best for the segmentation of digital paper forms.

A digital image of a medical form is a good medium for storing data because it guarantees that the medical form will be stored as it is but it is not a good medium for analysis. Data stored as an image occupies a huge amount of space and in limited bandwidth transferring images is significantly slower and may even be impossible. In scale, the whole system may fail because of its inability to transfer huge amounts of data. This study will provide an approach how to get the useful data from digital images of paper forms and to minimize the storage space used.

## 1.2 Research Objectives

### 1.2.1 General Objective

To create a system that stores and retrieves useful information from digital images of paper forms to provide a fast and convenient way for viewing the information on a screen.

### 1.2.2 Specific Objectives

1. To provide a modified version of the current medical examination form that will be more appropriate in the process.
2. To implement an algorithm that extracts the medical examination form from the mobile captured image.
3. To prepare the extracted image for segmentation by implementing a dewarping algorithm.
4. To implement an algorithm that extracts and identifies the multiple sections of the form.
5. To extract the data on the identified sections as strings.
6. To create a database that stores extracted strings of the form.

## 1.3 Scope and Limitations of the Research

The study focuses on the segmentation of specific types of forms and its implementation will cover selected image processing algorithms from reviewed studies. Currently, medical examination forms exists for the use of the GetBetter system.

These forms are to be modified to be more compatible with the algorithms to be used. The test images that will be used in the study will mainly be a variety of mobile captured images of the modified forms.

The performance of image segmentation techniques depend heavily on the quality of the image. It is important to note that the quality of the image may vary depending on the hardware used to take the picture, on the physical condition of the paper form and on the circumstances the image was taken. Because of this variance, it cannot be guaranteed that image segmentation process will work for all kinds of images and conditions, however an algorithm that will work under the worst condition will be employed to guarantee maximum effort and performance instead. For the purpose of GetBetter, the test images in this study will be those which are captured on a Samsung tablet since that is what is currently being used.

## 1.4 Significance of the Research

People are growing to be more dependent on technology and because of this almost everything is becoming digital including physical documents. Providing a way to make these documents presentable and accessible on various devices is now an important matter.

The GetBetter Tele-Diagnosis System lacks the functions which can support the transformation of the forms in images into a better digital representation of the form. Currently the system does not provide an interface that allows doctors to obtain sections of a patients medical examination form separately. Providing functions that will allow a systematic approach in the diagnosis process is a step further in enabling the doctors to become more productive and the system more convenient.

The resulting database of images which contain information about the patients can then be used by an Optical Character Recognition system to replace the images with actual values represented as strings or numbers. This will produce a more comprehensible information that the users and system can utilize.

# Chapter 2

# Review of Related Literature

## 2.1 Studies on Object Detection for Paper Forms

A study done by George and Lakshmi (n.d.), uses Canny Edge Detection to find objects in the image. To identify the object in the image, a query image is used as a template to be a point of comparison. Correlation coefficient with the edges of template image for each object found in the image is computed and whichever object has the highest correlation value must be the object of interest. Though the study has merits it also comes with problems such as, the size of the template image and search image will never be the same and that will significantly affect the correlation coefficient. Thus a technique that is independent from the image size must be explored.

One possible technique dependent from the size of the image is shape analysis. A paper done by Teh and Chin (1989) discusses a technique used to identify the dominant points in an enclosed curvature using the assumptions that dominant points are located at maximum curvatures of the shape. Thus a square or rectangle contains four dominant points, Octagon with eight and so on. One possible problem with this technique is differentiating noise shapes with important shapes. The location of important shapes must be clearly defined so that out of placed shapes will be discarded. This technique can be very useful on detecting the fields on the form, however, similar to the object detection by the canny algorithm, this technique does not take advantage of colors.

If the form has distinct colors, color based image segmentation techniques can be used.Rathore et al. (2012) proposes the use of L*A*B as features and K-means to segment the image. This technique can be applied to the paper forms by assigning distinct colors to objects of interests in the image. By knowing the distinct colors, it can easily be found in the image by K-means.

Correlation coefficient, Shape analysis, and color based segmentation are useful techniques if the location of the object is not known. However for paper forms, each location of the field is already known, given that the type of paper form can be identified. It is the paper form itself that has an unknown location within the image. Nguyen et al. (2011) discusses an approach used on an multiple choice answer sheet that takes advantage of the known location. They transform the paper in the correct orientation using hough transform and normalize it through resizing. By doing so, each objects in the multiple choice answer sheet can be extracted using its known normalized location and size.

| Author | Techniques Used For Object Detection |
|---|---|
| George and Lakshmi (n.d.) | Canny Edge Detection algorithm, Correlation |
| Teh and Chin (1989) | Curvature Measure, Number of points |
| Rathore et al. (2012) | L*A*B features, K-means |
| Nguyen et al. (2011) | Hough Transform, Normalization |

Table 2.1: Object Detection Summary

## 2.2 Studies on Improving Readability

Once the form has been found in the image, to improve readability it must be dewarped to fix the skewness and orientation. A paper by Stamatopoulos et al. (2008) proposes a two step dewarping process. The first step is to map the projection of a warped image to a 2D rectangular box . Next step is fine adjustment of the letters by looking for the words and aligning it. Though for the purpose of the forms the fine adjustment step wont work because the proposed word detection does not work on handwritten characters. Projecting the form to a 2D rectangular box will make it easier find the fields because it can then be mapped using its location on the x y plane.

After transformation, to aid the field searching and readability the document should be cleaned of its noise. Depending on the type of noise Farahmand et al. (2013) proposes different kinds of technique like thresholding, fuzzy logic based, and morphology based. It is important to identify the type of noise the forms will be most likely be exposed to before implementing such algorithms.

| Author | Techniques Used for improving readability |
|---|---|
| Stamatopoulos et al. (2008) | Projection of curved image to 2D rectangular box |
| Farahmand et al. (2013) | Noise Reduction |

Table 2.2: Improving Readability Summary

## 2.3 Image Segmentation

Huang et al. (2015) presented a method of workpiece recognition and location based on Open Source Computer Vision (OpenCV). The paper mentions how workpiece recognition and location technology is important in automatic production. The method has three stages which are preprocessing, contour extraction, and workpiece recognition and location. The preprocessing includes image graying, mean filter, adaptive threshold segmentation, and image binarization. Contour extraction makes use of the findContours function of OpenCV on the resulting binary image of the preprocessing stage. The contours with small perimeters or complex shapes are removed and the remaining contours are filled up and used for another contour extraction with the findContours function. A template image, which is the image of the workpiece, undergoes the same process to be used for template matching in the next stage. Using the OpenCV function matchShapes, the contours of the first image, or the identifying image, is matched with the contours of the template. Once the shapes match, the position is obtained by calculating the mass center of its contour. Based on experimental results, the method can realize workpiece recognition and location and can satisfy real time demand.

In a study by Gupta et al. (2006), document layouts are extracted automatically and segments of the document are analyzed and bounded given its spatial arrangement. The process involves two major steps which are layout extraction and layout analysis. Layout extraction deals with merging rectangular regions until a global layout structure is generated. Layout analysis involves defining a model of a paper layout, performing feature extraction on the resulting image, and then classification. Technical documents such as scanned journals and conference proceedings were used for testing. The system was implemented using Visual C++ and Open Source Computer Vision (OpenCV) library.

Patel et al. (2015) presented a low cost optical mark recognition (OMR) system called CheckIt. The system is developed using Python and the Open Source Computer Vision (OpenCV) library for the back end and Android for the front end. It is low cost because it utilizes open source technology and does not need a scanning hardware. The method involves image graying, resizing, adaptive histogram equalization, adaptive thresholding, blurring, canny edge detection, contour extraction, affine transformation, and score calculation. Based on the studys results, the algorithm has high accuracy and speed. It was tested on 310 images with an average processing time of 3 seconds per image.

| Authors | Techniques Used for Image Segmentation |
|---|---|
| Huang et al. (2015) | Contour Extraction and Template Matching using the OpenCV library |
| Gupta et al. (2006) | Segmentation algorithms using the OpenCV library |
| Patel et al. (2015) | Contour Extraction using the OpenCV library |

Table 2.3: Image Segmentation Summary

## 2.4 Optical Character Recognition

Vuong and Do (2014) presented a multilanguage name card reader on an Android platform. The method was implemented with the Open Source Computer Vision (OpenCV) library and Tesseract Optical Character Recognition (Tesseract OCR). The proposed system has six steps which are language selection, retrieval of image from the camera or SD card, preprocessing, optical character recognition (OCR), pattern matching, and contact information adding. Preprocessing involves image resizing, noise reduction, card area detection, image graying, and locally adaptive binarization. The Tesseract OCR is then used on the resulting binary image. Different information is extracted from the OCR step and to deal with this the content is matched with a predefined format to only obtain the necessary contents. The final step then adds the information extracted to the contact list of the device. Although the system is unable to correctly extract information in cases with complex background and blurred image, the results still showed a satisfactory number with high accuracy over 90

| Authors | Techniques Used for Optical Character Recognition |
|---|---|
| Vuong and Do (2014) | Segmentation algorithms<br>using the OpenCV library and Tesseract<br>Optical Character Recognition |

Table 2.4: Optical Character Recognition Summary

# Chapter 3

# Research Methodology

This chapter lists and discusses the specific steps and activities that will be performed by the proponent to accomplish the project. The discussion covers the activities from pre-proposal to Final Thesis Writing. It also includes an initial discussion on the theoretical framework to be followed.

## 3.1 Research Activities

### 3.1.1 Testing different image segmentation approaches.

Each member of the group will try a different, approach for image segmentation. The results will be compared and the best approach will be used as the primary algorithm for image segmentation. This is done to ensure that the best possible algorithm is implemented, and the system will work as best as possible.

### 3.1.2 Redesigning of medical forms

Depending on the image segmentation technique, the medical form may be redesigned to aide the process. The member testing the image segmentation technique may opt to redesign the form if necessary.

## 3.2 Calendar of Activities

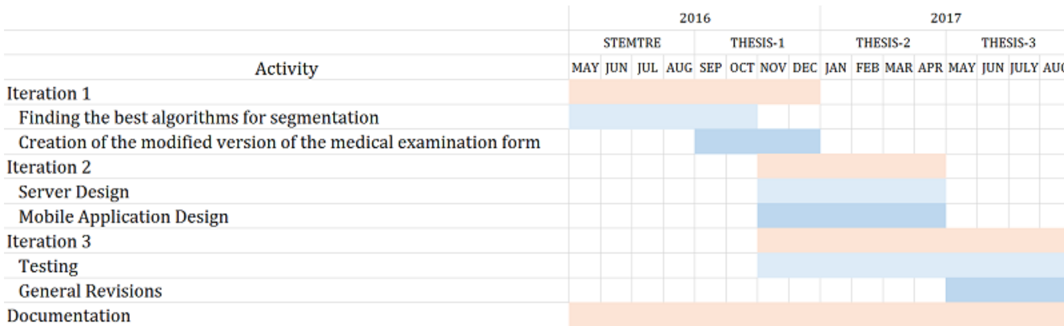



Figure 3.1: Gantt Chart of Activities

# Appendix A

# Diagrams and Other Documentation Tools

## A.1 Process Flow

**The system has two parts: client and server.**

### A.1.1 Client Side

The client is implemented on an android tablet. The client is responsible for taking pictures, segmenting it to relevant parts and extracting the relevant information as strings. OpenCV will be used as the primary library for image operations and Tesseract as the primary library for Optical character recognition.

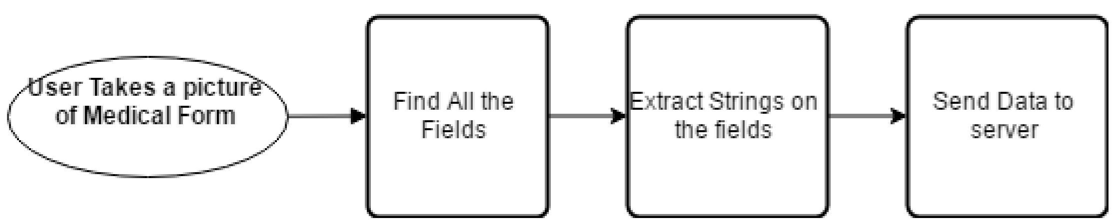



Figure A.1: Client Side

### A.1.2 Server Side

The server side is responsible for storing the data received from the client. MySQL will be used as the database and the server side will be implemented on java.

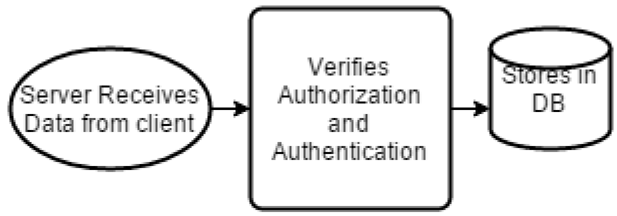
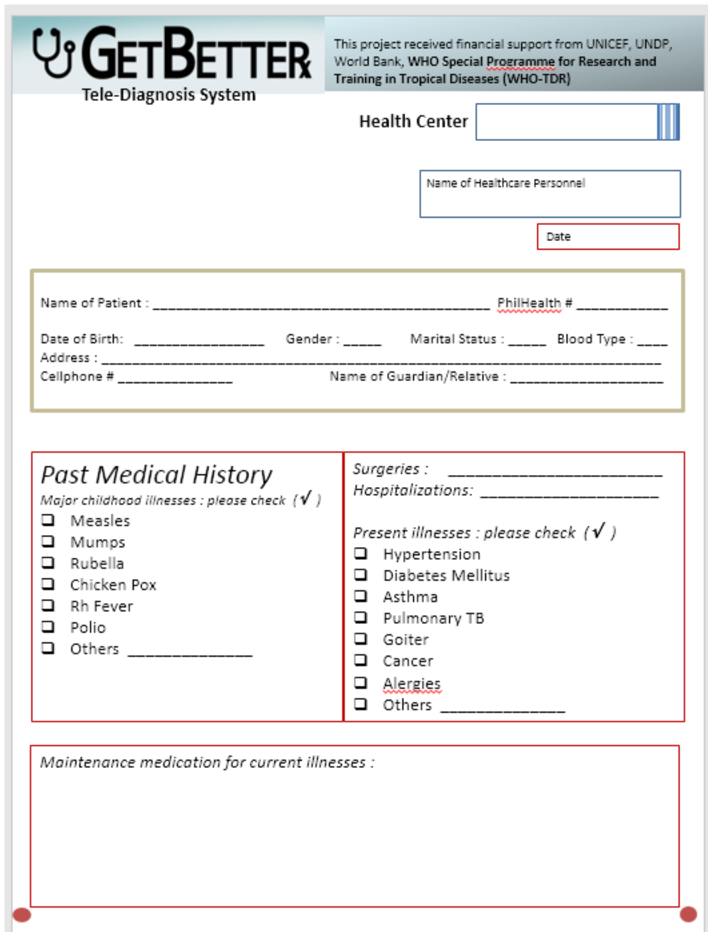



Figure A.2: Server Side

## A.2 Medical Examination Forms currently used by the GetBetter Tele-Diagnosis System.

### A.2.1 First Form



GETBETTER
Tele-Diagnosis System

This project received financial support from UNICEF, UNDP, World Bank, **WHO Special Programme for Research and Training in Tropical Diseases (WHO-TDR)**

**Health Center**

Name of Healthcare Personnel

Date

Name of Patient : ________________________________________ PhilHealth # ___________

Date of Birth: _______________ Gender : _____ Marital Status : _____ Blood Type : ____

Address : ______________________________________________________________________

Cellphone # ______________ Name of Guardian/Relative : __________________

*Past Medical History*

*Major childhood illnesses : please check (√ )*

- ❑ Measles
- ❑ Mumps
- ❑ Rubella
- ❑ Chicken Pox
- ❑ Rh Fever
- ❑ Polio
- ❑ Others _____________

*Surgeries :* ______________________

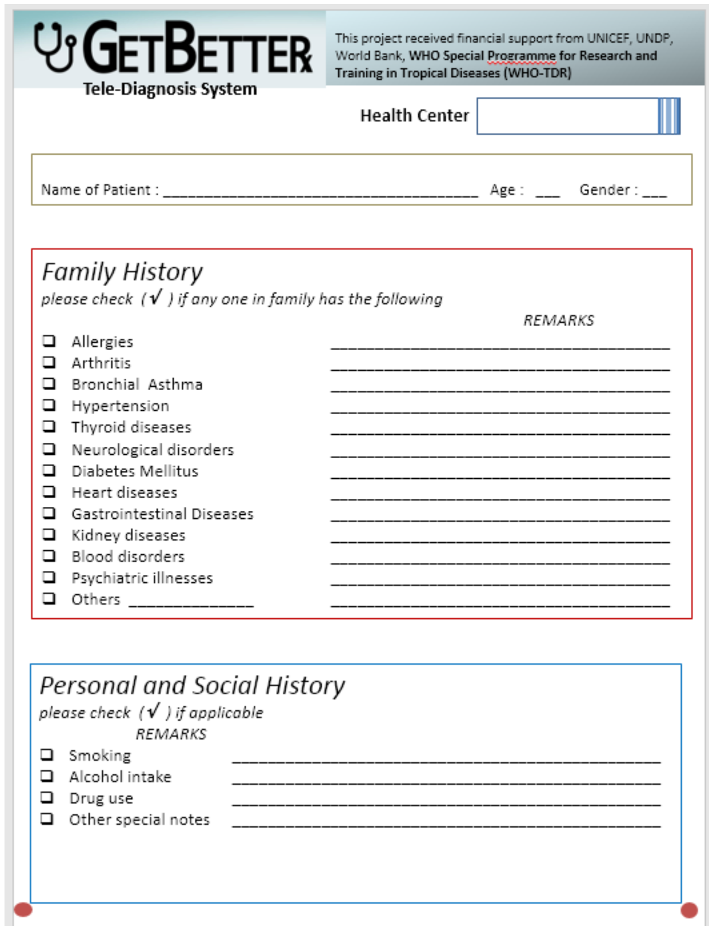
*Hospitalizations:* ___________________

*Present illnesses : please check (√ )*

- ❑ Hypertension
- ❑ Diabetes Mellitus
- ❑ Asthma
- ❑ Pulmonary TB
- ❑ Goiter
- ❑ Cancer
- ❑ Alergies
- ❑ Others _____________

*Maintenance medication for current illnesses :*

### A.2.2 Second Form



GETBETTER
Tele-Diagnosis System

This project received financial support from UNICEF, UNDP, World Bank, **WHO Special Programme for Research and Training in Tropical Diseases (WHO-TDR)**

**Health Center**

Name of Patient : ____________________________________ Age : ___ Gender : ___

*Family History*

*please check ( √ ) if any one in family has the following*

*REMARKS*

- ❑ Allergies ________________________________________
- ❑ Arthritis ________________________________________
- ❑ Bronchial Asthma ________________________________________
- ❑ Hypertension ________________________________________
- ❑ Thyroid diseases ________________________________________
- ❑ Neurological disorders ________________________________________
- ❑ Diabetes Mellitus ________________________________________
- ❑ Heart diseases ________________________________________
- ❑ Gastrointestinal Diseases ________________________________________
- ❑ Kidney diseases ________________________________________
- ❑ Blood disorders ________________________________________
- ❑ Psychiatric illnesses ________________________________________
- ❑ Others ______________ ________________________________________

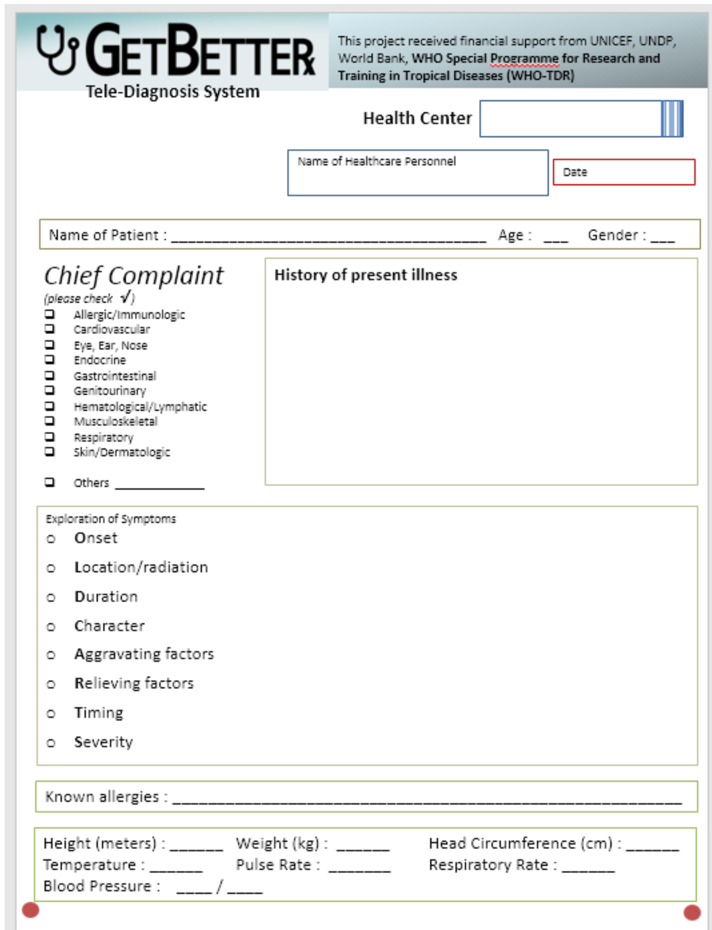
*Personal and Social History*

*please check ( √ ) if applicable*

*REMARKS*

- ❑ Smoking ________________________________________
- ❑ Alcohol intake ________________________________________
- ❑ Drug use ________________________________________
- ❑ Other special notes ________________________________________

### A.2.3 Third Form



GetBetter

Tele-Diagnosis System

This project received financial support from UNICEF, UNDP, World Bank, **WHO Special Programme for Research and Training in Tropical Diseases (WHO-TDR)**

**Health Center**

Name of Healthcare Personnel

Date

Name of Patient : ____________________________________ Age : ___ Gender : ___

*Chief Complaint*

*(please check ✓)*

- ❑ Allergic/Immunologic
- ❑ Cardiovascular
- ❑ Eye, Ear, Nose
- ❑ Endocrine
- ❑ Gastrointestinal
- ❑ Genitourinary
- ❑ Hematological/Lymphatic
- ❑ Musculoskeletal
- ❑ Respiratory
- ❑ Skin/Dermatologic
- ❑ Others ___________

**History of present illness**

Exploration of Symptoms

- o Onset
- o Location/radiation
- o Duration
- o Character
- o Aggravating factors
- o Relieving factors
- o Timing
- o Severity

Known allergies : ________________________________________________________

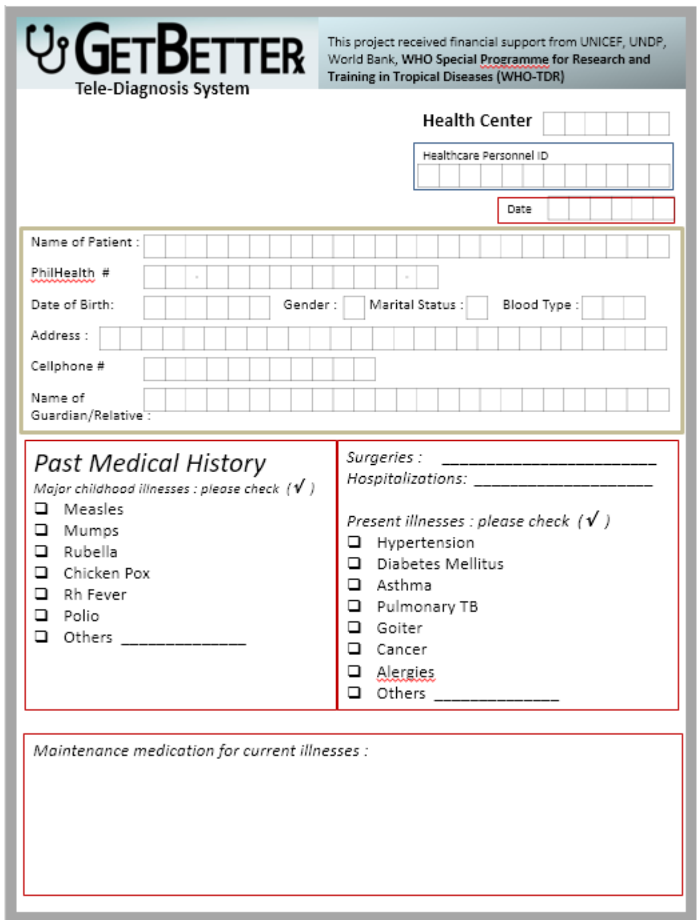
Height (meters) : ______ Weight (kg) : ______ Head Circumference (cm) : ______

Temperature : ______ Pulse Rate : _______ Respiratory Rate : ______

Blood Pressure : ____ / ____

## A.3 Medical Examination Forms in preparation for the Optical Character Recognition system

### A.3.1 First Form



GETBETTER

Tele-Diagnosis System

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**Health Center**

Healthcare Personnel ID

Date

Name of Patient :

PhilHealth #

Date of Birth:

Gender :

Marital Status :

Blood Type :

Address :

Cellphone #

Name of Guardian/Relative :

*Past Medical History*

*Major childhood illnesses : please check (√ )*

- ❑ Measles
- ❑ Mumps
- ❑ Rubella
- ❑ Chicken Pox
- ❑ Rh Fever
- ❑ Polio
- ❑ Others ____________

*Surgeries :* ______________________

*Hospitalizations:* __________________

*Present illnesses : please check (√ )*

- ❑ Hypertension
- ❑ Diabetes Mellitus
- ❑ Asthma
- ❑ Pulmonary TB
- ❑ Goiter
- ❑ Cancer
- ❑ Alergies
- ❑ Others ____________

*Maintenance medication for current illnesses :*

### A.3.2 Second Form

GETBETTER
Tele-Diagnosis System

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**Health Center**

Name of Patient :

Age :    Gender :

*Family History*

*please check (√) if any one in family has the following*

*REMARKS*

- ❑ Allergies ____________________
- ❑ Arthritis ____________________
- ❑ Bronchial Asthma ____________________
- ❑ Hypertension ____________________
- ❑ Thyroid diseases ____________________
- ❑ Neurological disorders ____________________
- ❑ Diabetes Mellitus ____________________
- ❑ Heart diseases ____________________
- ❑ Gastrointestinal Diseases ____________________
- ❑ Kidney diseases ____________________
- ❑ Blood disorders ____________________
- ❑ Psychiatric illnesses ____________________
- ❑ Others ____________ ____________________

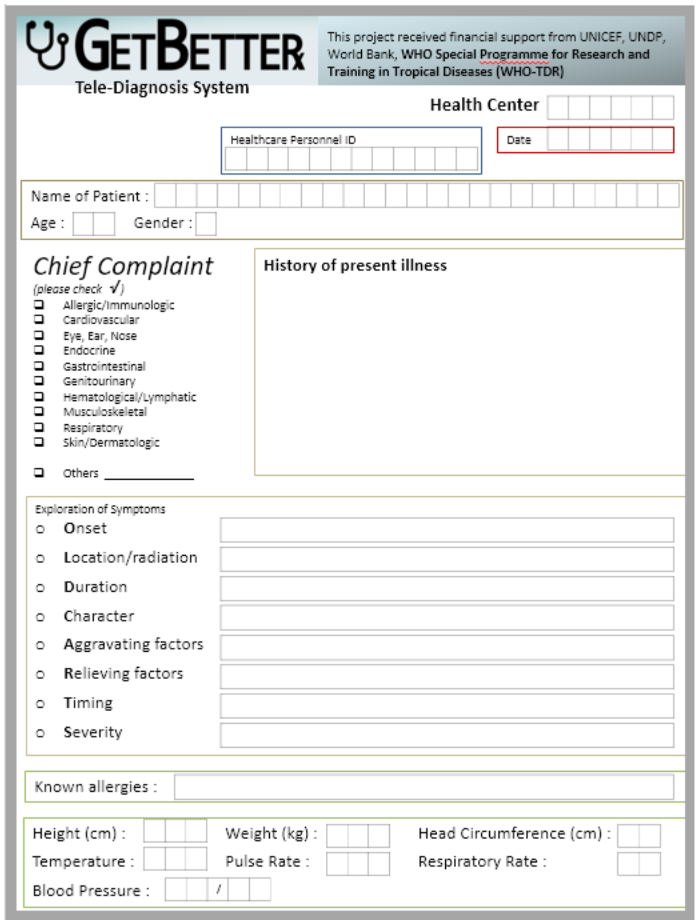
*Personal and Social History*

*please check (√) if applicable*

*REMARKS*

- ❑ Smoking ____________________
- ❑ Alcohol intake ____________________
- ❑ Drug use ____________________
- ❑ Other special notes ____________________

### A.3.3 Third Form



GETBETTER

Tele-Diagnosis System

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**Health Center**

Healthcare Personnel ID

Date

Name of Patient :

Age :

Gender :

*Chief Complaint*

*(please check ✓)*

- ❑ Allergic/Immunologic
- ❑ Cardiovascular
- ❑ Eye, Ear, Nose
- ❑ Endocrine
- ❑ Gastrointestinal
- ❑ Genitourinary
- ❑ Hematological/Lymphatic
- ❑ Musculoskeletal
- ❑ Respiratory
- ❑ Skin/Dermatologic
- ❑ Others ____________

**History of present illness**

Exploration of Symptoms

- ○ Onset
- ○ Location/radiation
- ○ Duration
- ○ Character
- ○ Aggravating factors
- ○ Relieving factors
- ○ Timing
- ○ Severity

Known allergies :

Height (cm) :

Weight (kg) :

Head Circumference (cm) :

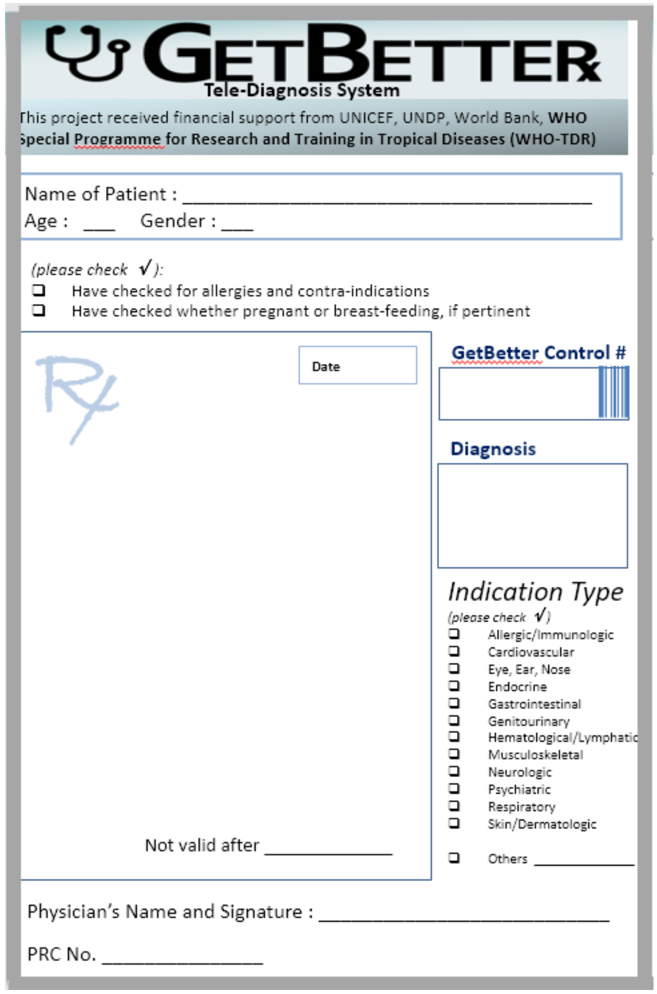
Temperature :

Pulse Rate :

Respiratory Rate :

Blood Pressure : /

### A.3.4 Fourth Form



GETBETTER
Tele-Diagnosis System

This project received financial support from UNICEF, UNDP, World Bank, **WHO Special Programme for Research and Training in Tropical Diseases (WHO-TDR)**

Name of Patient : ________________________________________

Age : ___ Gender : ___

*(please check √):*

- ❑ Have checked for allergies and contra-indications
- ❑ Have checked whether pregnant or breast-feeding, if pertinent

Rx

Date

Not valid after _____________

**GetBetter Control #**

**Diagnosis**

*Indication Type*

*(please check √)*

- ❑ Allergic/Immunologic
- ❑ Cardiovascular
- ❑ Eye, Ear, Nose
- ❑ Endocrine
- ❑ Gastrointestinal
- ❑ Genitourinary
- ❑ Hematological/Lymphatic
- ❑ Musculoskeletal
- ❑ Neurologic
- ❑ Psychiatric
- ❑ Respiratory
- ❑ Skin/Dermatologic
- ❑ Others ___________

Physician's Name and Signature : ______________________________

PRC No. ________________

### A.3.5 Fifth Form

GETBETTER

Tele-Diagnosis System

This project received financial support from UNICEF, UNDP, World Bank, **WHO Special Programme for Research and Training in Tropical Diseases (WHO-TDR)**

Name of Patient : ______________________________________

Age : ___ Gender : ___

*(please check √):*

- ❑ Have checked for allergies and contra-indications
- ❑ Have checked whether pregnant or breast-feeding, if pertinent

Rx

Date

Not valid after ____________

**GetBetter Control #**

**Diagnosis**

*Indication Type*

*(please check √)*

- ❑ Allergic/Immunologic
- ❑ Cardiovascular
- ❑ Eye, Ear, Nose
- ❑ Endocrine
- ❑ Gastrointestinal
- ❑ Genitourinary
- ❑ Hematological/Lymphatic
- ❑ Musculoskeletal
- ❑ Neurologic
- ❑ Psychiatric
- ❑ Respiratory
- ❑ Skin/Dermatologic
- ❑ Others __________

Physician's Name and Signature : ___________________________

PRC No. _______________

# Appendix B

# Theoretical and/or Conceptual Framework

## B.1 Image Pre-Processing

Image Pre-Processing involves the transformation of raw digital images of paper forms to a more useful digital image. This process removes noise and outputs a gray-scale and a binary version of the image to aide the image segmentation process. Farahmand, et al. (2013), proposed different approaches to clean image. These approaches is applicable on our images and will be the main reference for cleaning the images.

## B.2 Image Segmentation

Image segmentation is the process of extracting all relevant parts of the image. The main goal is to extract and identify each field in the medical form. Different image segmentation techniques relevant to the study includes, color, contour and location based segmentation discussed by different authors in the related literature. Different approaches will be tried to determine the best and most robust way.

## B.3 Optical Character Recognition

Optical Character Recognition translates digital images of characters to string characters. This process is necessary because the data retrieved in the medical forms will be stored as strings. Tesseract, an open-source Optical Character Recognition (OCR) engine that has a very high correct recognition rate (Vuong and Do, 2014) will be used . Tesseract OCR works well in an Android Application as seen on Vuong and Dos (2014) proposed system. Similarly to OpenCV, it only needs to be imported and its functions can easily be used.

# Appendix C

# Resource Persons

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