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Majmaah University
Ministry of Higher Education
College of Science Al Zulfi

المملكة العربية السعودية
جامعة المجمعة
وزارة التعاليم العالي
كلية العلوم بالزلفي

Aging Prediction Using Photoplethysmogram Waveform Analysis

Student Affairs System
For College of science Al Zulfi
Department of Computer Science and Information

Graduation Project

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CHAPTER ONE

1.1 Introduction

Machine Learning is used to create predictive models by learning features from datasets. Different machine learning algorithms are used in these studies to select specific biomarkers to make age prediction. Ageing has a huge impact on human health and economy, but its molecular basis – regulation and mechanism – is still poorly understood.

By today, more than three hundred genes (almost all of them function as protein-coding genes) have been related to human ageing. Although individual ageing-related genes or some small subsets of these genes have been intensively studied, their analysis as a whole has been highly limited. To fill this gap, for each human protein we extracted 21000 protein features from various databases, and using these data as an input to state-of-the-art machine learning methods, we classified human proteins as ageing-related or non-ageing-related.

As humans, we have a knack for prediction another person's age quite accurately just by glancing at their face. Although age prediction may seem relatively simple to us, computers have a much more difficult time performing the task. Principal Component Analysis (PCA), also known as Karhunen Loeve expansion, is a classical feature extraction and data representation technique widely used in the areas of pattern recognition and computer vision.

This work examines the ability of predicting age using the Photoplethysmogram (PPG) signal. In addition, it seeks the study of aging effects on the changes of PPG's morphology. The PPG signal is an optically obtained plethysmogram in which it reflects changes in blood volume with each heartbeat. We built on the hypothesis that aging will introduce roundness to the contour of PPG waveform. Features extraction will take place to extract some indices in which they may assist in predicting aging. Reflection index (RI) represents a promising parameter that we can count on it to

produce a surrogate measure for aging prediction. The importance of aging prediction is associated to changes in cardiovascular activities and loss of elasticity of arterial wall. When small and medium arteries start stiffening, early detection of atherosclerosis in sub-clinical settings can be investigated and detected.

1.2 Problem statement

Aging is one-way journey in which we have no choice to escape it unless death has come. The most hazardous scenario behind aging is that our bodies start to develop silent killing diseases, especially, chronic diseases like diabetes and heart attacks and brain strokes. These diseases are normally developed without sensed symptoms in which they are very hard to be detected before the risk comes. The possibility of developing a predictive tool that could bring some signals that promote early detection and prediction of chronic diseases will be a great novelty.

1.3 Objectives

Investigate the effects of aging on arterial wall
Review the literatures about the related works
Develop a predictive tool for the aging prediction

1.4 scope of study

This study will conduct a group-based sample of Saudi people only in Zulfi, KSA

CHAPTER TWO

Literature Reviews

This study examines, cardiovascular diseases are the main cause of death world-wide. Stiffing of the arterial wall is normally related, with the beginning, or the progression, of atherosclerosis.

Atherosclerosis plays an important role in the loss of the elastic. Properties of arteries walls. Thereby, atherosclerosis might cause, harmful damage to arteries which in turn might cause.Cardiovascular disease and erectile dysfunction. we analyzed the variations in Photoplethysmogram (PPG) signal shape by exploring its peaks positions and timings, in order to start quantifying of its peaks to gain better understanding of the nature of this signal. The results showed that PPG peaks positions and timings differ clearly from one subject to another, which may lead to relate these changes to their diseases and their disorders. A customized algorithm for peaks determination and PPG wave parts separation was developed. The variation of photoplethysmogram (PPG) morphology based on a sample by recording PPG finger tips from erectile dysfunction (ED) patients. Nine PPG indexes are calculated along with carotid intima- media thickness (CIMT) for all patients.The measured parameters are statistically analyzed and their association is shown in results section.These results show that PPG can be used to analyze cardiovascular disorders and supplement existing methods of analyzing arterial conditions. The risk of cardiovascular diseases may damage the endothelium cells which may cause atherosclerosis.
Arterial stiffness can be measured noninvasively by the use of photoplethysmogram ,(PPG) technique. This research presents the variations of PPG morphology with age. Based on a sample of 65 subjects whom. having established erectile dysfunction (ED), the study proposed to assess the variations of PPG contour at two sites of measurements (right and left index finger). The study concluded that PPG timing indices are equal in both right and left hand.

That PPG is highly affected by aging which noteworthy to be observed by the variations of PPG contour. Since we advance in age, PPG becomes more rounded which in turn make PPG inflection point and dicrotic notch less pronounced.As a conclusion, RI may provide a window to small and medium arteries compliance and it can be a measure of small and medium arteries stiffness. When small and medium arteries start stiffening, early detection of atherosclerosis in sub-clinical settings can be investigated and detected. Predict and classify patients into diabetic and nondiabetic subjects based on

age. and four independent variables extracted from the analysis of photoplethysmogram (PPG) morphology in time domain.And the Cardiac arrhythmia is a group of conditions in which the heart beat is either irregular, too slow or too fast. Although most arrhythmias are not serious, they may increase risk, of heart failure or stroke. Millions of people around the world suffer. from cardiac arrhythmia. Sudden cardiac arrest causes about 50% of all casualties due to CVDs and ventricular arrhythmias constitute to about 80% of all deaths caused by sudden cardiac arrest. Most arrhythmias do not show marked symptoms which makes it harder to detect them. A typical heart activity of a normal subject and a arterial fibrillation patient is shown in. Abnormal electrical activity causes arrhythmic heart. The study has two main stages, the first one was the analysis of PPG
waveform to extract b/a, RI, DiP, and SPt indices. These parameters contribute by some means to the prediction of diabetes. They were statistically significant and correlated with the HbA1C test. The second stage was building a neural network. Based classifier to predict diabetes. The model showed an accuracy of 90.2% in training phase and an accuracy of 85.5% in testing phase. The findings of this research work may contribute towards the prediction of diabetes in early stages. Also, the proposed classifier showed a high accuracy in predicting the existence of diabetes in Saudi people population.

CHAPTER THREE

Research Methodology

What is Agile Methodology?

AGILE methodology is a practice that promotes continuous iteration of development and testing throughout the software development lifecycle of the project. Both development and testing activities are concurrent unlike the Waterfall model.

The agile software development emphasizes on four core values.

1.Individual and team interactions over processes and tools

2.Working software over comprehensive documentation

3.Customer collaboration over contract negotiation

4.Responding to change over following a plan

In this Software Engineering tutorial, you will learn

Agile Vs Waterfall Method

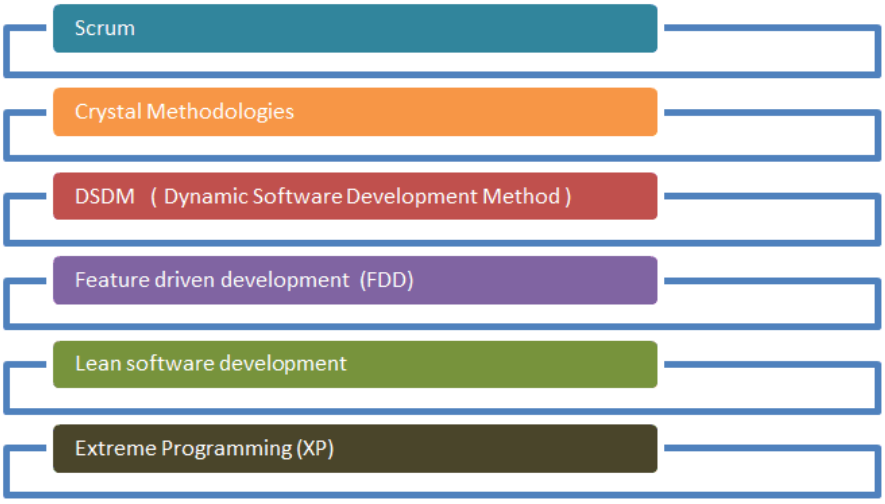
Agile and Waterfall model are two different methods for software development process. Though they are different in their approach, both methods are useful at times, depending on the requirement and the type of the project.

Agile Model	Waterfall Model
• Agile method proposes incremental and iterative approach to software	• Development of the software flows sequentially from start point to end

design	point.
• The agile process is broken into individual models that designers work on	• The design process is not broken into an individual models
• The customer has early and frequent opportunities to look at the product and make decision and changes to the project	• The customer can only see the product at the end of the project
• Agile model is considered unstructured compared to the waterfall model	• Waterfall model are more secure because they are so plan oriented
• Small projects can be implemented very quickly. For large projects, it is difficult to estimate the development time.	• All sorts of project can be estimated and completed.
• Error can be fixed in the middle of the project.	• Only at the end, the whole product is tested. If the requirement error is found or any changes have to be made, the project has to start from the beginning
• Development process is iterative, and the project is executed in short (2-4) weeks iterations. Planning is very less.	• The development process is phased, and the phase is much bigger than iteration. Every phase ends with the detailed description of the next phase.
• Documentation attends less priority than software development	• Documentation is a top priority and can even use for training staff and upgrade the software with another team
• Every iteration has its own testing phase. It allows implementing regression testing every time new functions or logic are released.	• Only after the development phase, the testing phase is executed because separate parts are not fully functional.
• In agile testing when an iteration end, shippable features of the product is delivered to the customer. New features are usable right after shipment. It is useful when you have good contact with customers.	• All features developed are delivered at once after the long implementation phase.
• Testers and developers work together	• Testers work separately from developers
• At the end of every sprint, user acceptance is performed	• User acceptance is performed at the end of the project.
• It requires close communication with developers and together analyze requirements and planning	• Developer does not involve in requirement and planning process. Usually, time delays between tests

	and coding

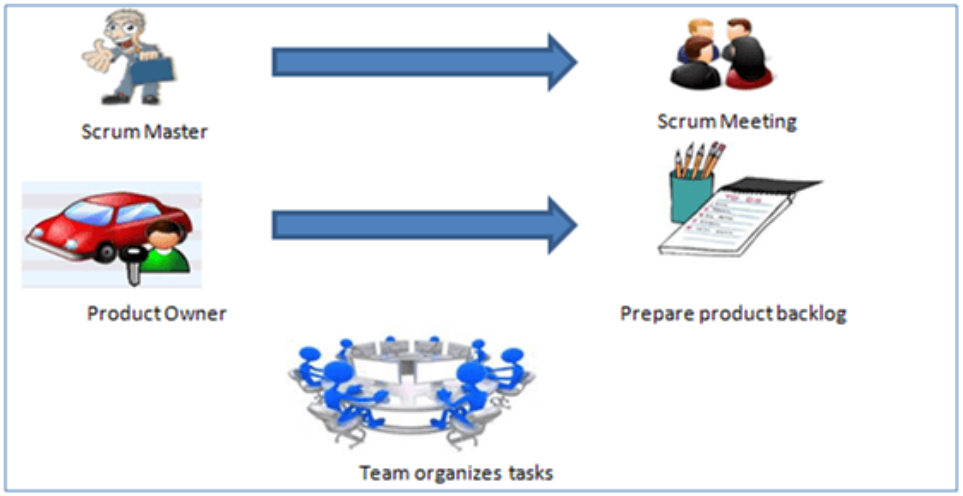
Agile Methodology



There are various methods present in agile testing, and those are listed below:

Scrum

SCRUM is an agile development method which concentrates specifically on how to manage tasks within a team-based development environment. Basically, Scrum is derived from activity that occurs during a rugby match. Scrum believes in empowering the development team and advocates working in small teams (say- 7 to 9 members). It consists of three roles, and their responsibilities are explained as follows:



- Scrum Master
  - Master is responsible for setting up the team, sprint meeting and removes obstacles to progress

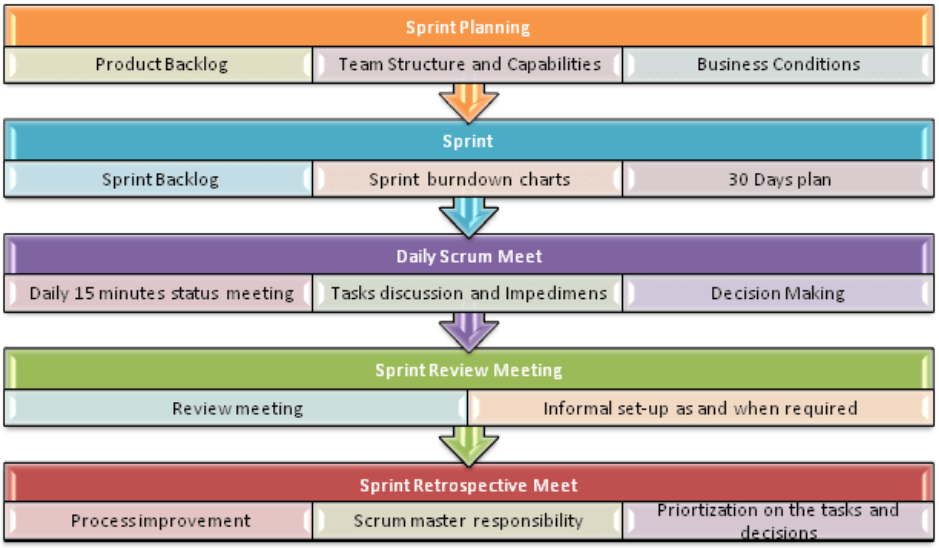
- Product owner
  - The Product Owner creates product backlog, prioritizes the backlog and is responsible for the delivery of the
    delivery of the functionality at each iteration
- Scrum Team
  - Team manages its own work and organizes the work to complete the sprint or cycle

Product Backlog

This is a repository where requirements are tracked with details on the no of requirements(user stories) to be completed for each release. It should be maintained and prioritized by Product Owner, and it should be distributed to the scrum team. Team can also request for a new requirement addition or modification or deletion

Scrum Practices

Practices are described in detailed:



Process flow of Scrum Methodologies:

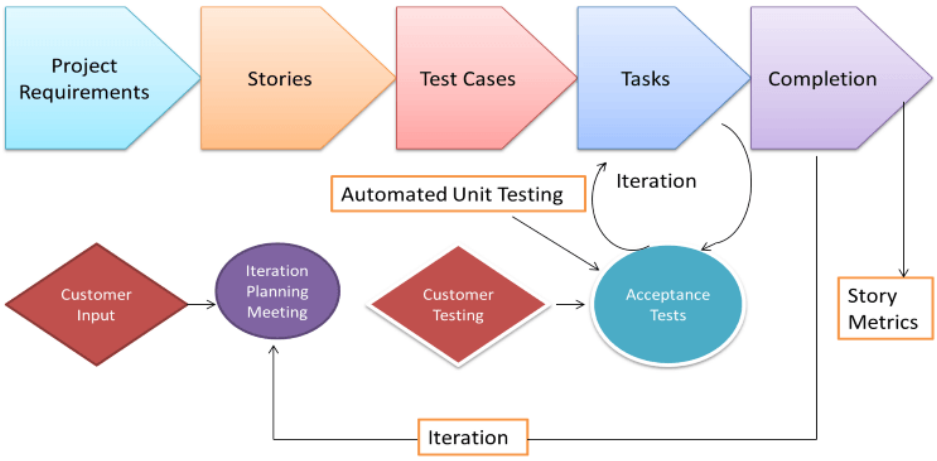
Process flow of scrum testing is as follows:

- Each iteration of a scrum is known as Sprint
- Product backlog is a list where all details are entered to get the end-product
- During each Sprint, top user stories of Product backlog are selected and turned into Sprint backlog

- Team works on the defined sprint backlog
- Team checks for the daily work
- At the end of the sprint, team delivers product functionality

eXtreme Programming (XP)

Extreme Programming technique is very helpful when there is constantly changing demands or requirements from the customers or when they are not sure about the functionality of the system. It advocates frequent "releases" of the product in short development cycles, which inherently improves the productivity of the system and also introduces a checkpoint where any customer requirements can be easily implemented. The XP develops software keeping customer in the target.



Extreme Programming (XP)

Business requirements are gathered in terms of stories. All those stories are stored in a place called the parking lot.

In this type of methodology, releases are based on the shorter cycles called Iterations with span of 14 days time period. Each iteration includes phases like coding, unit testing and system testing where at each phase some minor or major functionality will be built in the application.

Phases of eXtreme programming:

There are 6 phases available in Agile XP method, and those are explained as follows:

Planning

- Identification of stakeholders and sponsors
- Infrastructure Requirements

- Security related information and gathering
- Service Level Agreements and its conditions

Analysis

- Capturing of Stories in Parking lot
- Prioritize stories in Parking lot
- Scrubbing of stories for estimation
- Define Iteration SPAN(Time)
- Resource planning for both Development and QA teams

Design

- Break down of tasks
- Test Scenario preparation for each task
- Regression Automation Framework

Execution

- Coding
- Unit Testing
- Execution of Manual test scenarios
- Defect Report generation
- Conversion of Manual to Automation regression test cases
- Mid Iteration review
- End of Iteration review

Wrapping

- Small Releases
- Regression Testing
- Demos and reviews
- Develop new stories based on the need
- Process Improvements based on end of iteration review comments

Closure

- Pilot Launch
- Training
- Production Launch
- SLA Guarantee assurance
- Review SOA strategy
- Production Support

There are two storyboards available to track the work on a daily basis, and those are listed below for reference.

- Story Cardboard
  - This is a traditional way of collecting all the stories in a board in the form of stick notes to track daily XP activities. As this manual activity involves more effort and time, it is better to switch to an online form.
- Online Storyboard
  - Online tool Storyboard can be used to store the stories. Several teams can use it for different purposes.

Crystal Methodologies

Crystal Methodology is based on three concepts

1. **Chartering:** Various activities involved in this phase are creating a development team, performing a preliminary feasibility analysis, developing an initial plan and fine-tuning the development methodology

2. **Cyclic delivery:** The main development phase consists of two or more delivery cycles, during which the

a. Team updates and refines the release plan

b. Implements a subset of the requirements through one or more program test integrate iterations

c. Integrated product is delivered to real users

d. Review of the project plan and adopted development methodology

3. **Wrap Up:** The activities performed in this phase are deployment into the user environment, post- deployment reviews and reflections are performed.

Dynamic Software Development Method (DSDM)

DSDM is a Rapid Application Development (RAD) approach to software development and provides an agile project delivery framework. The important aspect of DSDM is that the users are required to be involved actively, and the teams are given the power to make decisions. Frequent delivery of product becomes the active focus with DSDM. The techniques used in DSDM are

1. Time Boxing

2. MoSCoW Rules

3. Prototyping

The DSDM project consists of 7 phases

1. Pre-project
2. Feasibility Study
3. Business Study
4. Functional Model Iteration
5. Design and build Iteration
6. Implementation
7. Post-project

Feature Driven Development (FDD)

This method is focused around "designing & building" features. Unlike other agile methods, FDD describes very specific and short phases of work that has to be accomplished separately per feature. It includes domain walkthrough, design inspection, promote to build, code inspection and design. FDD develops product keeping following things in the target

1. Domain object Modeling
2. Development by feature
3. Component/ Class Ownership
4. Feature Teams
5. Inspections
6. Configuration Management
7. Regular Builds
8. Visibility of progress and results

Lean Software Development

Lean software development method is based on the principle "Just in time production". It aims at increasing speed of software development and decreasing cost. Lean development can be summarized in seven steps.

1. Eliminating Waste
2. Amplifying learning
3. Defer commitment (deciding as late as possible)
4. Early delivery
5. Empowering the team
6. Building Integrity
7. Optimize the whole

Kanban

Kanban originally emerged from Japanese word that means, a card containing all the information needed to be done on the product at each stage along its path to completion. This framework or method is quite adopted in software testing method especially in agile testing.

Scrum Vs Kanban

Scrum	**Kanban**
• In scrum technique, test must be broken down so that they can be completed within one sprint	• No particular item size is prescribed
• Prescribes a prioritized product backlog	• Prioritization is optional
• Scrum team commits to a particular amount of work for the iteration	• Commitment is optional
• Burndown chart is prescribed	• No particular item size is prescribed
• Between each sprint, a scrum board is reset	• A Kanban board is persistent. It limits the number of items in workflow state
• It cannot add items to ongoing iteration	• It can add items whenever capacity is available
• WIP limited indirectly	• WIP limited directly
• Timeboxed iterations prescribed	• Timeboxed iterations optional

Agile metrics:

Metrics that can be collected for effective usage of Agile is:

- Drag Factor
    - Effort in hours which do not contribute to sprint goal

    - Drag factor can be improved by reducing number of shared resources, reducing the amount of non-contributing work
    - New estimates can be increased by percentage of drag factor -New estimate = (Old estimate+drag factor)
- Velocity
    - Amount of backlog(user stories) converted to shippable functionality of sprint
- No of Unit Tests added
- Time interval taken to complete daily build
- Bugs detected in an iteration or in previous iterations
- Production defect leakage

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(CERTIFICATE BY STUDENT)

This is to certify that the project titled **"Aging Prediction Using Photoplethysmogram Waveform Analysis"** submitted by me(**AlMalik Alhazmi, 361103347**) under the supervision of **Dr. Yousef Qawqzeh** for award of Bachelor degree of the Majmaah University carried out during the Semester 2, 2019-2020 embodies my original work.

Signature in full: ----------

Name in block letters:

Student ID:

Date: