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Usage of Model Driven Environment for the Classification of ECG features: A Systematic Review

UZAIR IQBAL[1,2], TEH YING WAH[1], MUHAMMAD HABIB UR REHMAN[1,3], AND QURAT-UL-AIN MASTOI[1]

[1]Department of Information Systems, Faculty of Computer Science and Information Technology, University of Malaya, Kuala Lumpur 50603, Malaysia
[2]Department of Software Engineering, Faculty of Computer Science and Engineering, National University of Modern Languages, Islamabad 44000, Pakistan
[3]Department of Computer Science, National University of Computer and Emerging Sciences, Lahore 54000, Pakistan

Corresponding authors: Uzair Iqbal (uzair.iqbal@siswa.um.edu.my) and Teh Ying Wah (tehyw@um.edu.my)

ABSTRACT Electrocardiography (ECG) constitutes a perfect and primary diagnostic tool for measuring the different morbidity conditions of the heart in the context of different heart diseases and arrhythmia. Various studies have proposed different techniques of classification of ECG features and defined the parametric structure of different features of ECG. This paper is primarily designed to provide a more accurate classification by inducting the concept of a model-driven environment (MDE). Such induction works on the basis of reusable factors that are fitted to the state-of-the-art parametric structure of the ECG features. Some issues and challenges related to the embedding process are highlighted in the form of research questions. The aim of this paper is to provide the solutions to these research questions. The literature review is completed in two phases. In the first phase, those articles are collected that have been published in IEEE Xplore, ACM Library, Science Direct, and Springer, from 2008 to 2017.The second phase as a part of the execution stage is completed at the three different levels of the rectification process by adhering to the Kitchen ham guideline. At the first level, articles are filtered according to title and abstract. At the second level, articles are filtered according to specific eligibility criteria, and at the last level, articles are selected based on the skills of different domain experts (authors) by checking the quality assessment parameters. The significance of MDE in the classification of different ECG features is reflected in their compatibility with the research questions. Furthermore, future directions are proposed that depict the significance of dependencies involvement in classification analysis of ECG. These future directions are identified based on the planning and execution of our operational investigation and our critical observation of the existing gaps between dependencies of features classification that is the major cause of cardiovascular diseases.

INDEX TERMS Software metrics, classification algorithms, electrocardiography, model driven environment.

I. INTRODUCTION

Over the last two decades, the use of ever more advancing technology has resulted in the enhancement of many working models in different domains. Healthcare constitutes such a domain where the use of technology is increasing day by day. Healthcare systems have always merited particular attention due to their urgency and the involved risk factors. Given these two factors, not even the minutest detail ought to be ignored at any stage of the process. There is a need to incrementally work on the improvement of accuracy and the raising of sensitivity levels. The extraction of different features in electrocardiography (ECG) highlights the primary core activities of the heart. During the complete ECG process, any presence of ambiguity creates a significant impact on the patient's condition [3]. Thus, removing such ambiguous portions in the ECG is highly desirable and commendable for technologists and researchers. After reviewing the literature, a hybrid method of identification of unusual patterns in ECG through the novel concept of deep classification is proposed. These unusual patterns are identified by using different classification techniques modeled through embedding the concept of the model-driven environment.

TABLE 1. Abbreviations section.

Abbreviations	Description
ECG	Electrocardiography
MI	Myocardial infarction
AMM	Agile Maturity Model
AMME	Agile Method Model Engineering
XP	Extreme Programming
FDD	Feature Driven Development
MDE	Model Driven Environment
MDA	Model Driven Architecture
R-Scrum	Review-Scrum
HMM	Hidden Markov Model

This study introduces the new concept of deep classification with the help of previous studies and covers the three factors of traceability, maintainability, and reusability. The first task is to trace these three factors in the previous research work in the most effective manner. After exploring the existing literature, our findings suggest that certain pieces of software and models are recognized as the best possible tools to identify the tractability factor. In the light of the existing literature, agile models are mostly used in software development organizations. Of all the agile models, Scrum can be identified as the most established and widely used methodology for the incremental development of software. Review-Scrum (R-Scrum) constitutes the updated version of Scrum that is implemented in the more sizeable scalable software projects [6], [9]. Feature driven development (FDD), Extreme Programming (XP), and agile method model engineering (AMME) constitute the key models of these agile models. Other data models are autoregressive modeling, the Hidden Markov model (HMM), and others statistical models. The scope of this article is to create room for the analysis of ECG features through the model base solution.

This systematic study is executed by applying the Kitchen ham method and attempts to deliver the concept of in-depth classification. Operational investigations of this study are executed in stages. The first stage constitutes the collection phase. In this stage, a collection of 41 articles of different ECG classification techniques is produced by using the defined range of selection (2008 to 2017). These 41 articles are passed through the first rectification stage that fetches the 25 articles from the article bank and excludes 16 articles by using the filtration of title and abstract. After the completed rectification stage, the article bank passes to the second stage. In the second rectification stage, 19 articles are selected from a group of 25 articles that have passed through the checkpoint of eligibility criteria. Those 19 articles then pass through the third rectification stage based on their quality assessment. 11 articles are accepted and eight articles are excluded based on their low-quality measurements. Those 11 articles constitute the core of this SLR and used to produce the answers to the research problems.

During the exploration activity of searching for different articles, it is observed that no work seems to exist on the modeler classification of different ECG features. Thus, according to our best knowledge we are the first research team which proposes the model-driven classification whereby ECG features are classified by way of combining different terminologies of software and data models. These models are worked in the model-driven environment. A summary of our contributions is stated below.

1. Generating the idea in the shape of ECG modeler classification by adopting the model-driven environment.
2. Highlighting the usage of the incremental approach of agile models which fits the model based ECG features classification. Such integrated part of incremental approach delivers the factors of traceability and maintainability in the process of modular classification.
3. Highlighting the core issue of ECG feature classification that involves dependencies in ECG features not previously highlighted in other works.

The remaining sections of this paper are organized as follows: section II presents the research methodology; section III discusses the selected articles in the form of bibliometric analysis; section IV contains the answers to the queries mentioned in section II in the form of research questions; and section V identifies the unresolved issues and gaps in the existing research, which leave room for future research whose directions are discussed in section VI. The conclusion of our research work is presented in section VII.

A. ABBREVIATIONS

Abbreviations are highlighted in table 1.

II. RESEARCH METHODS

During the operational activity of reviewing the existing literature, those techniques and algorithms are highlighted that deliver the good accuracy and sensitivity levels in terms of classifying the different ECG features. However, there are identified certain gaps, which call for further research and improvement. Such improvements are also required in the ECG classification process which highlights the dependencies between different ECG features. This study proposes the composition of a hybrid of software modeling and other types of modeling that relies on the model-driven environment. The model-based classification process of ECG depends on a number of research problems that are translated into specific research questions.

A. RESEARCH QUESTIONS

RQ1: How it is possible that model-driven environment (MDE) and model-driven architecture (MDA) work for ECG classification process?

RQ2: How does data modeling embed in feature classifications of ECG?

RQ3: What are the critical parameters of agile models that suit the feature classification process of ECG?

B. DATA SOURCE

This SLR is designed by using the four primary electronic databases. In table 2 below, DB-name represents the name of the database along with the URL of the database.

TABLE 2. Electronic databases.

Id	DB_name	URL
DB1	IEEE Xplore	http://ieeexplore.ieee.org
DB2	Springer Link	http://link.springer.com
DB3	Science Direct	http://www.sciencedirect.com
DB4	ACM Libarary	https://dl.acm.org/

The purpose of this SLR is to deliver the model based ECG classified solution that provides in-depth ECG feature classification along with the trackback element. The extraction of articles for the composition of SLR is done by the query string. The items of a string that are picked on the basis of research problems are represented in the form of research questions. This paper reflects the hybrid approach for the solution of these identified research problems in the form of model driven classification.

(1). "Model Driven Environment" OR "Model Driven Architecture"

(2). "Agile modeling "OR "Scrum" OR "Review-Scrum" OR 'iScrum"

(3). "Statistical Model" OR "Data modeling" OR "Hidden Markov Model." OR "Auto aggressive modeling"

(4). "ECG morphology analysis" OR "ECG feature extraction" OR "ECG feature analysis."

These four commands work in the form of a string whereby the string builder delivers the relative collection of literature with the help of conjunction ("AND") and Disjunction ("OR") operators. The result-oriented strings are stated as below.

("Model Driven Environment" OR "Model Driven Architecture") AND ("Agile modeling" OR "Scrum" OR "iScrum") AND ("Statistical Model" OR "Data modeling" OR "Markov Hidden Model" OR "Auto aggressive modeling") AND ("ECG morphology analysis" OR "ECG feature extraction" OR "ECG feature analysis")

C. INCLUSION AND EXCLUSION POLICY

Once the articles have been fetched from the above mentioned query string, the next stage is to apply rectification processes, among them being the exclusion and inclusion policies that are imposed on selected articles. Table 3 contains a short summary of these policies.

D. DATA EXTRACTION SCHEME

In this stage, a scheme of data extraction is executed on the basis of certain parameters. It primarily focuses on mapping the research questions with the data bank of articles. The execution of this scheme is displayed in table 4. The selected articles are listed in appendix-A. The following vital items are worked in the extraction scheme that highlights title, author publication venue, publication year, research approach, method (ECG feature analysis, model-based classification), and the research questions addressed.

E. LITERATURE QUALITY MEASUREMENT

This stage constitutes part of the last level of the rectification process. The seminal part of this SLR measures the quality of the selected articles, which it assesses on the basis of several pre-defined checkpoints. These checkpoints are designed with the help of another brainstorming activity that centers on our understanding of both areas (ECG features classification and model based solution). According to the structure of table 5, the judgment level is represented in the form of "YES", "NO", and "PARTIALLY" decision checkers.

F. SELECTED SEARCH ARTICLE

This systematic study is executed by following the above plan. Initially, a collection of 41 articles from different data banks is used to build the foundation of SLR. In the next step are defined the three different levels of rectification applied in the whole structure of the said SLR. In the first stage of rectification are obtained 25 articles (exclusion of 16 articles based on their unsatisfactory title and abstract). In the second stage, 19 of the 25 articles are fetched and six articles discarded on the basis of unsatisfactory results after checking the requirements of eligibility criteria. In the third and last stage, eight articles are excluded based on their poor literature quality measurement score. Figure 4 shows a complete pictorial representation of the above discussion and the rectification levels R1 to R3.

The final level of the rectification process is of concern in terms of the development of the research solutions that are reflected in the form of research questions. The last level of rectification is executed by using the baseline of the article score generator table as listed in appendix-B. This table contains 19 articles that are further investigated on the basis of the expert reviews. In this process, five different reviewers are worked on the databank of 19 articles that delivers the scores for each article. These reviews are represented in the form of the article score generator table whose execution is dependent on the table 5. With the help of table 5, each assessor reviews the 19 articles and generates the score. The table shown in Appendix-B 1 contains the satisfactory result ("YES"), 0 highlights the disappointing result ("NO"), and 0.5 shows the partial result. Altogether only 11 articles have scored

TABLE 3. Inclusion and exclusion policies.

Inclusion Criteria	
IP1	Research Articles that imposes the model base solution
IP2	Articles introducing any scenario base solution for ECG Analysis
IP3	Articles highlighted model-based classification for different ECG features.
IP4	Solution oriented articles be a part of literature
Exclusion Criteria	
EP1	Articles delivered unclear Process or methodology
EP2	Articles without any validation proposed techniques
EP3	Articles other than the English language

TABLE 4. Scheme of article extraction.

Data Source	Information unit
P_ID	
Title	
Author	
Publication Year	
Publication Type (Journal /Conference)	
Publication Venue	
Research Method /Approach(Experimental / SLR / A case study)	
Research Questions Address up	*Directly:* *Indirectly*:

TABLE 5. Quality measurement parameters.

Sr #	Quality Assessment queries	Decision Checker
1	Research goals reflects in article	Yes No Partially
2	Model-based classification techniques map up with research designed	Yes No Partially
3	Limitations or challenges are stated	Yes No Partially
4	Research objectives are clearly defined	Yes No Partially

above or equal to 3. This scenario indicates the threshold value of all selected articles is equal to or above than 3. Figure 1 below displays the pattern of the assessors marked scores.

A more in-depth discussion of the process requires the scrutiny of the minor details of this study.The context of this SLR is to deliver the best possible way of sorting the solutions of the research problems presented in the form of the research questions. The first step requires understanding the nature of the ECG feature analysis and knowing how model oriented work is suitable for the classification of different ECG features. This purpose is achieved by assigning five experts (assessors) who evaluate the selected articles.

The levels constitute the core part of the reviewing process. The 11 core articles are used to compile the answers to the posed research questions. Figure 2 shows a pictorial model of the domain knowledge of each article's assessor. Following the sequential step of the previous showcase, figure 3 shows the scoring view of each article, which also reflects the scoring trend of each reviewer.

III. DISCUSSION

The most striking part of the SLR is the discussion section containing the overview of the selected articles and the mapping details. In this section, the first part is a bibliometric overview of selected articles. This bibliometric structure of the selected articles is represented in table 6 and table 7.

The above table represents the informational view. Such bibliometric structure highlights few key factors that are paper id (Pid_), references, year of publication (year), total number of citation (citation counter), average citation of each article on the basis of year (avg citations count/year)

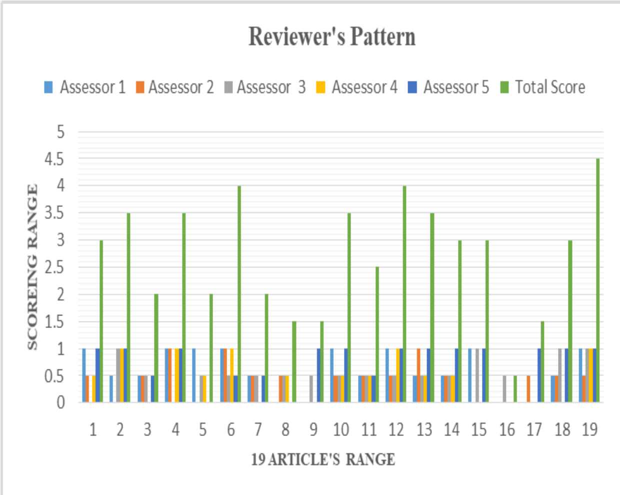

FIGURE 1. Showcase of the reviewer pattern.

FIGURE 2. Expert knowledge towards both domains.

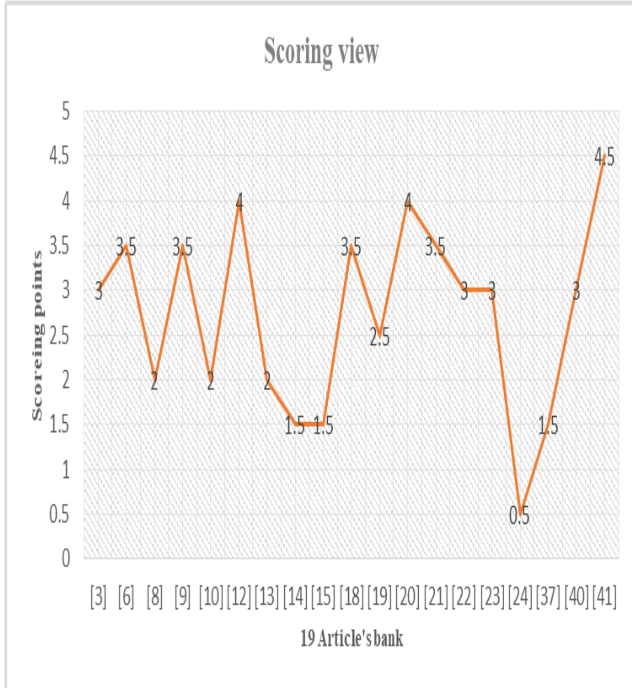

FIGURE 3. Scoring rate of each article.

and research questions address up (RQ1, RQ2, and RQ3). Based on the bibliometric structure as represented in table 6, the informational view of the selected articles displays the basis of the publication mode, publisher, reference and year. Table 7 contains the publication mode in reference to the publication (journal mode or conference mode), in addition to the publisher factor. Figure 5 gives a graphical view of the representation ratio of the publication mode.

In Figure 3, the range of selected articles from 2008 to 2017 indicates a maturity in both domains (software modeling and data modeling). However, it does not answer the question how the modeling can be used as a classification unit as such classification unit is to be embedded into the ECG features analysis. Here, the solutions of the predefined research questions are replicated based on the above query. The main purpose of this discussion of the selected articles is to address the research questions in relation to the defined literature. The first step consists of highlighting the age range of the selected articles. Figure 6 showcases the selected articles years of publication.

The second step consists of combining the results, primarily focused on highlighting the map of the defined research questions and their significance to the selected articles. This step plays a vital role in delivering the perfect solution for classifying the different ECG features by embedding the model base paradigm. The supporting unit of this theme is highlighted in figure 7 below showing the pictorial representation of the mapping trend of the research questions with regard to the selected articles.

In terms of deep classification solutions that are dependent on the mapping, such mapping heavily relies on the quality of the selected articles. The cross-checking of the quality of the articles is checked by the view of the previous history. Figure 8(a) gives a graphical representation in the form of citation counter that highlights the quality trend of each article. Using this trend rate makes it easy to identify the state-of-the-art work for further deep observations. The above findings regarding the research questions, mapping and citation counter of the selected articles function as connectors in the operational investigations that are used for compiling the results of this study.

The previous track record of the selected articles in the form of citation counts and average citations per year constitutes the key part in the operational investigations in the way of result compilation. Figure 8(b) highlights the citation average per year that also defines the quality structure of the selected articles.

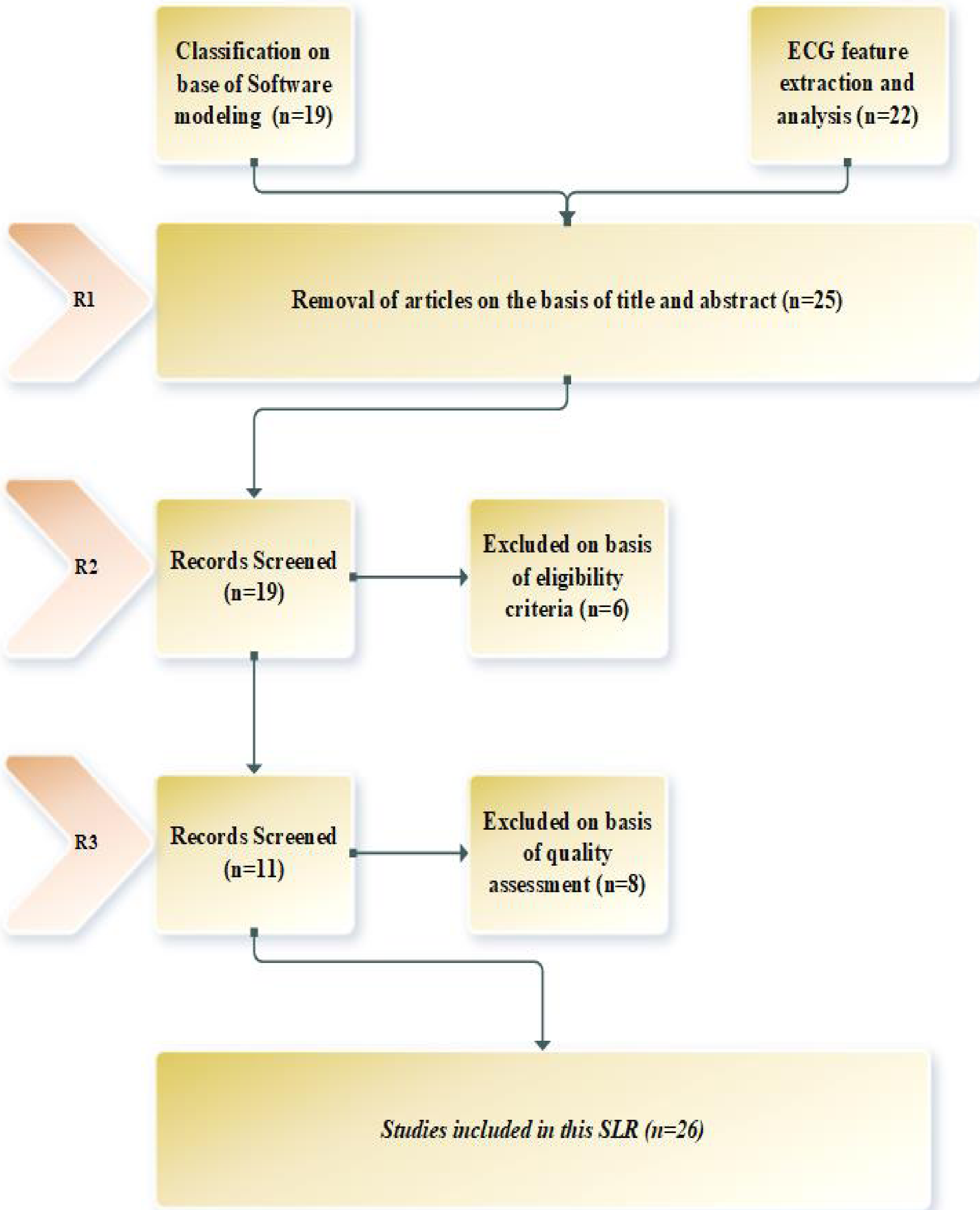

FIGURE 4. Article extraction in three stages.

IV. RESULTS

The most significant part of this SLR is completed by compiling the report in the form result. Such compilation is built based on the in-depth analysis of the selected articles. These selected articles represent high quality research as indicated by their citations. Here, the biggest challenge is posed by the articles published in 2017 as the citation counter produces a zero value. This means that the articles published in 2017 only

TABLE 6. Bibliometric view of selected articles.

Paper ID	Reference	Year	Citation counter	Avg. citations count/year	RQ1	RQ2	RQ3
Pid_1	[3]	2017	0	0	✓	✗	✓
Pid_2	[6]	2014	1	0.2	✓	✗	✓
Pid_3	[9]	2017	0	0	✓	✗	✓
Pid_4	[12]	2008	171	17.1	✗	✓	✗
Pid_5	[18]	2016	1	0.5	✓	✓	✓
Pid_6	[20]	2014	3	0.75	✓	✓	✗
Pid_7	[21]	2015	33	11	✓	✗	✓
Pid_8	[22]	2017	0	0	✓	✓	✗
Pid_9	[23]	2017	0	0	✓	✗	✗
Pid_10	[40]	2016	5	2.5	✗	✓	✗
Pid_11	[41]	2016	0	0	✓	✗	✓

TABLE 7. Information view of selected articles.

Paper ID	Reference	Year	Publication mode	Publisher
Pid_1	[3]	2017	Journal	Management
Pid_2	[6]	2014	Journal	International journal of scientific & technology research
Pid_3	[9]	2017	Journal	Modern education and computer science press
Pid_4	[12]	2008	Journal	Bulgarian journal of physics
Pid_5	[18]	2016	Journal	Elsevier
Pid_6	[20]	2014	Journal	Elsevier
Pid_7	[21]	2015	Conference	ACM
Pid_8	[22]	2017	Conference	healthinf
Pid_9	[23]	2017	Conference	healthinf
Pid_10	[40]	2016	Journal	Elsevier
Pid_11	[41]	2016	Conference	IEEE

discuss the methodologies, which point to solutions in the form of modular architecture. Figure 9 below shows the pictorial model containing the overview of the result compilation methodology.

A. RQ1: DRIVEN CLASSIFICATION OF ECG

Technology induction in the field of healthcare systems constitutes what can be considered a game changer. The introduction of new technology-based solutions creates a massive change in these systems. The ECG is considered the most sensitive and effective method in the diagnosis of different heart diseases. For the purpose of diagnostic solutions of different heart diseases, the category of disease needs to be classified. Several studies discuss the ways of improving the ECG classification techniques and algorithms [18]. Some studies discuss this classification in the form of the modular solution [20]–[23]. In this section, the predefined RQ1 is mapped up with those selected articles that indicated the classification solution in the form of models. Figure 10 below showcases a typical example of a model based ECG classification.

According to the scope of this study, our findings are related to the classification of ECG features through modular forms. In order to achieve this aim, we introduce the terminologies used in model-driven environment (MDE) and model-driven architecture (MDA) into the feature

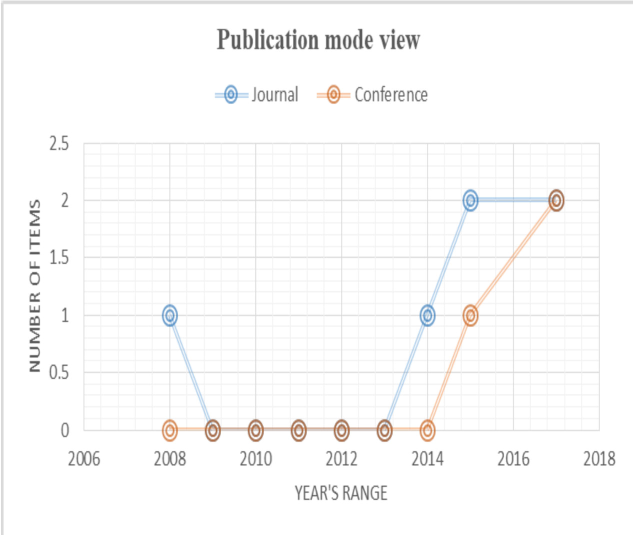

FIGURE 5. Graphical view of publication mode of selected articles.

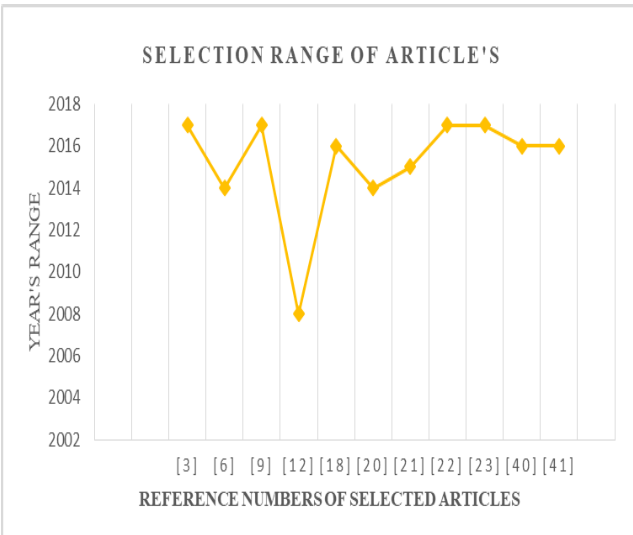

FIGURE 6. Graphical view of scoring range of articles per year.

classification of ECG. These terminologies are worked under the coverage of software modeling and are used in the software development as part of an incremental approach. However, the aim of the MDE and MDA is to deliver the structure of the defined solution in such form that the elements of traceability, maintainability, and reusability are possible. Based on these elements, several studies are found in our data bank of selected articles that highlight the model-based classification of ECG features. This model based classification indicates the MDE and MDA involvement in modeling by embedding the elements of traceability, maintainability, and reusability, which allow for a more effective classification including the trackback feature. All the data models are also categorized in MDE and MDA based on the fact that they incorporate the said elements (traceability, maintainability, and reusability).

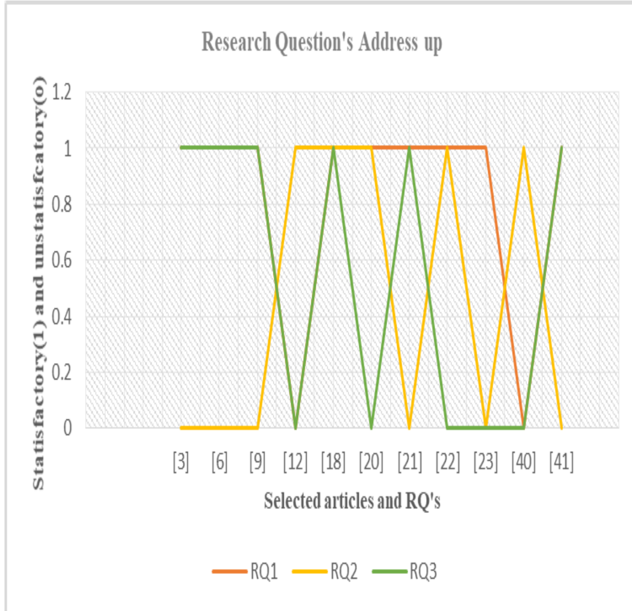

FIGURE 7. Mapping unit of research questions.

The autoregressive modeling and Hidden Markov model constitute ideal examples of the form of solution-oriented data modeling. According to the existing literature, these models possess a good trackback record in ECG feature classification. One study discusses the classification of the features of Atrial fibrillation (AF) in ECG signals by adopting the autoregressive modeling [20]. Similar to autoregressive modeling, Markov's hidden model is also used in ECG analysis in order to calculate the prediction factor along with the classification of different features.

B. RQ2: MODULAR CLASSIFICATION IN ECG

During the literature surveying process, some studies are found that propose superior algorithmic techniques to classify ECG features yet do not discuss their dependencies. In the context of searching the article data bank, the three defining elements (traceability, maintainability, and reusability) are useful in dependencies calculation. They are traced in the selected articles and address RQ2 in terms of executing the investigational process. A number of studies are found during this investigative process that complete the addressing process of RQ2. At any stage of constructing an ECG health care system, data modeling plays a vital role in the process of classification [12]. In the deep search into the selected articles, some studies can be identified that use the methodology of classifying ECG features with the help of models. Different data models are used to classify the different ECG features, for example on model driven urgent ambulance control systems, autoaggressive modeling for AF detection, and web-based health monitoring tools [18], [20], [22]. In such systems, a part of the feature classification of ECG reflected the MDE and MDA usable for every stakeholder. A different study proposes a model based solution following a language

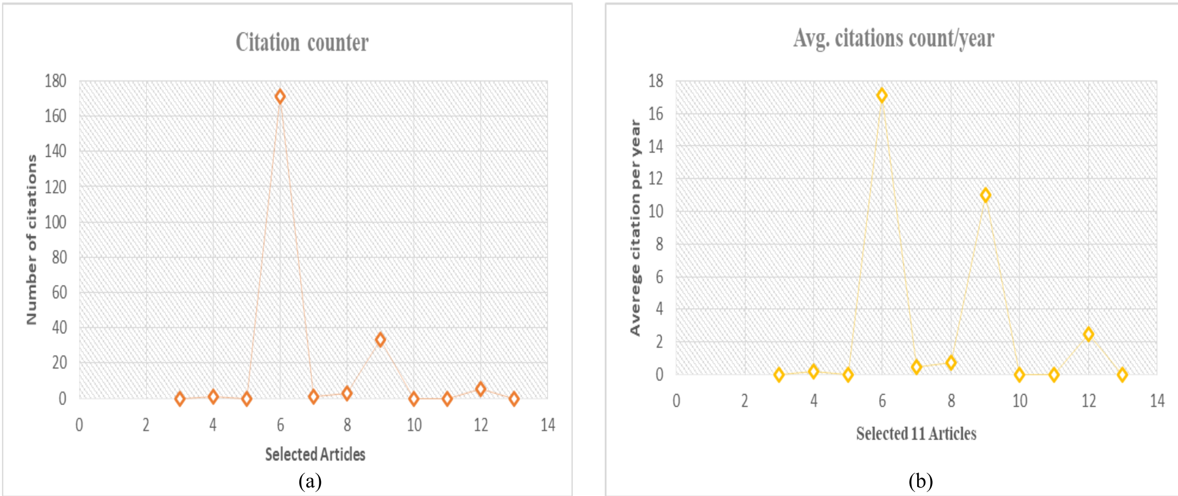

FIGURE 8. (a) Citation counter of selected articles. (b) Average Citation per year of each selected articles.

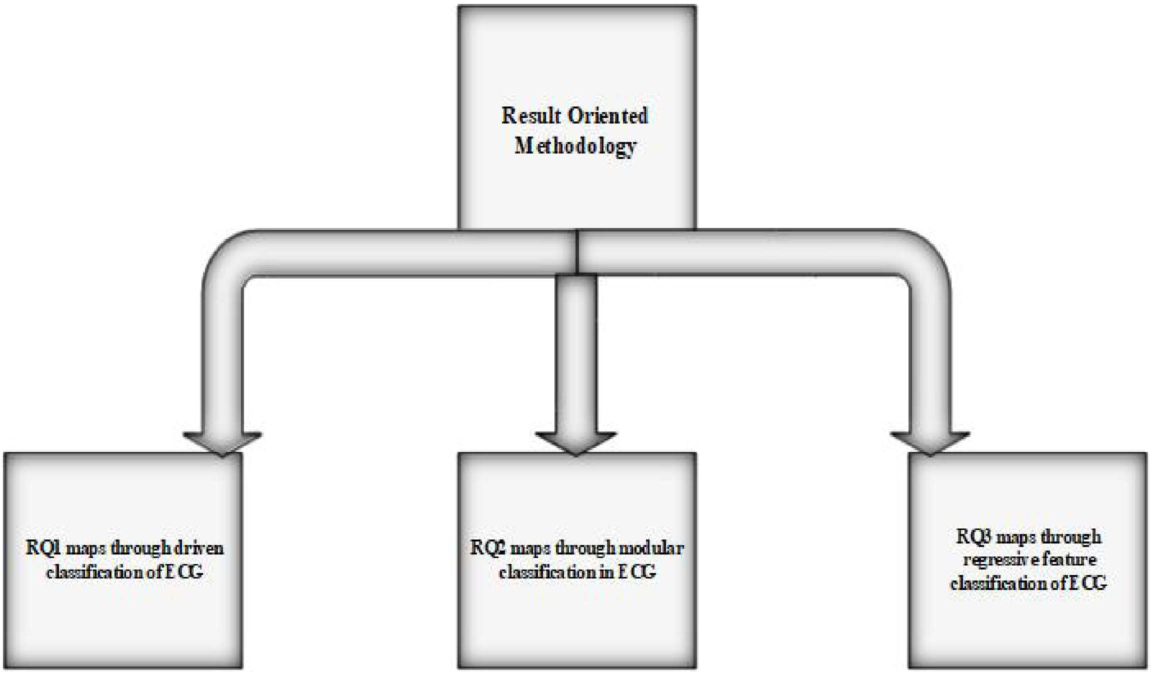

FIGURE 9. Result compilation in address up form of research questions.

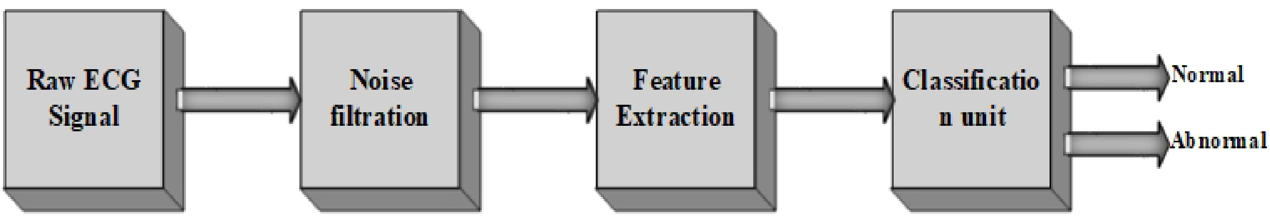

FIGURE 10. Block model of the primary ECG classification process.

model approach (DISCo) for the classification of time series data that map up the classification unit of ECG features [40]. Autoregressive modeling for the classification of AF is also included in the proposed data modeling studies.

C. RQ3: REGRESSIVE FEATURE CLASSIFICATION OF ECG

Nowadays software development is worked under the requirements of business or other specific purposes. The most striking approach in software construction constitutes

TABLE 8. Overall Schemes of Selected articles.

Data Source	Information unit
P_ID	1
Title	A Fuzzy Logic-Based System for Enhancing Scrum Method
Author	Mihailo Stupar, Pavle Milošević, Bratislav Petrovi.
Publication Year	2017
Publication Type (Journal /Conference)	Journal
Publication Venue	Journal of Sustainable Business and Management Solutions in Emerging Economies
Research Method /Approach(Experimental / SLR / A case study)	A case study
Research Questions Address up	*Directly:* ---------- *Indirectly*: RQ1,RQ3

Data Source	Information unit
P_ID	2
Title	Review-Scrum(R-Scrum) Introduction Of Model Driven Architecture (MDA) In Agile Methodology
Author	Uzair Iqbal, Ali Javed
Publication Year	2014
Publication Type (Journal /Conference)	Journal
Publication Venue	INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH
Research Method /Approach(Experimental / SLR / A case study)	A case study
Research Questions Address up	*Directly:* ----------------- *Indirectly*: RQ1,RQ3

Data Source	Information unit
P_ID	3
Title	IScrum: An Improved Scrum Process Model
Author	Sara Ashraf, Shabib Aftab
Publication Year	2017
Publication Type (Journal /Conference)	Journal
Publication Venue	International Journal of Modern Education and Computer Science
Research Method /Approach(Experimental / SLR / A case study)	A case study
Research Questions Address up	*Directly:* -------------- *Indirectly*: RQ1,RQ3

TABLE 8. *(Continued.)* **Overall Schemes of Selected articles.**

Data Source	**Information unit**
P_ID	4
Title	ECG Signal Analysis Using Wavelet Transforms
Author	C. Saritha, V. Sukanya, Y. Narasimha Murthy
Publication Year	2008
Publication Type (Journal /Conference)	Journal
Publication Venue	Bulgarian Journal of Physics
Research Method /Approach(Experimental / SLR / A case study)	Experimental method
Research Questions Address up	*Directly:* ------------ *Indirectly*: RQ2

Data Source	**Information unit**
P_ID	5
Title	Distributed data-driven platform for urgent decision making in cardiological ambulance control
Author	Sergey V.Kovalchuk, EvgeniyKrotov, Pavel A.Smirnov, Denis A.Nasonov, Alexey N.Yakovlev
Publication Year	2016
Publication Type (Journal /Conference)	Journal
Publication Venue	Future Generation Computer Systems
Research Method /Approach(Experimental / SLR / A case study)	Experimental method
Research Questions Address up	*Directly:* RQ1, RQ2 *Indirectly*: RQ3

Data Source	**Information unit**
P_ID	6
Title	Classification of ECG signal during Atrial Fibrillation using Autoregressive modeling
Author	K.Padmavathi, K.Sri Ramakrishna
Publication Year	2015
Publication Type (Journal /Conference)	Journal
Publication Venue	Procedia computer science
Research Method /Approach(Experimental / SLR / A case study)	Experimental method
Research Questions Address up	*Directly: RQ2*
	Indirectly: RQ1

TABLE 8. ***(Continued.)*** **Overall Schemes of Selected articles.**

Data Source	**Information unit**
P_ID	7
Title	Agile Modeling Method Engineering
Author	Dimitris Karagiannis
Publication Year	2015
Publication Type (Journal /Conference)	Conference
Publication Venue	Proceedings of the 19th Panhellenic Conference on Informatics
Research Method /Approach(Experimental / SLR / A case study)	Experinental method
Research Questions Address up	*Directly:* RQ3 *Indirectly*: RQ1

Data Source	**Information unit**
P_ID	8
Title	MonAT: A Visual Web-based Tool to Profile Health Data Quality
Author	Monica Noselli, Dan Mason, Mohammed A. Mohammed2,3 and Roy A. Ruddle1
Publication Year	2017
Publication Type (Journal /Conference)	Conference
Publication Venue	10th International Joint Conference on Biomedical Engineering Systems and Technologies(BIOSTEC)
Research Method /Approach(Experimental / SLR / A case study)	Experimental method
Research Questions Address up	*Directly:*------------------- *Indirectly*: RQ1,RQ2

Data Source	**Information unit**
P_ID	9
Title	Data-drivenWeb-based Intelligent Decision Support System for Infection Management at Point-Of-Care: Case-Based Reasoning Benefits and Limitations
Author	Bernard Hernandez, Pau Herrero, Timothy M. Rawson, Luke S. P. Moore, Esmita Charani,Alison H. Holmes and Pantelis Georgiou
Publication Year	2017
Publication Type (Journal /Conference)	Conference
Publication Venue	10th International Joint Conference on Biomedical Engineering Systems and Technologies(BIOSTEC)
Research Method /Approach(Experimental / SLR / A case study)	Experimental method
Research Questions Address up	*Directly: RQ1* *Indirectly*: --------------

TABLE 8. *(Continued.)* **Overall Schemes of Selected articles.**

Data Source	Information unit
P_ID	10
Title	DSCo: A Language Modeling Approach for Time Series Classification
Author	40. Daoyuan Li(B), Li Li, Tegawend´e F. Bissyand´e, Jacques Klein, Yves Le Traon
Publication Year	2016
Publication Type (Journal /Conference)	Journal
Publication Venue	Machine Learning and Data Mining in Pattern Recognition
Research Method /Approach(Experimental / SLR / A case study)	Experimental method
Research Questions Address up	*Directly:* -------------- *Indirectly*: RQ2

Data Source	Information unit
P_ID	11
Title	Identifying the Contextual Relationship among the Agile adoption factors through Interpretive Structural Modeling
Author	41. Shruti Sharma, Nitasha Hasteer, S.P Mishra, Jean-Paul Van Belle
Publication Year	2016
Publication Type (Journal /Conference)	Conference
Publication Venue	International Conference on Information Technology (InCITe) - The Next Generation IT Summit on the Theme - Internet of Things: Connect your Worlds
Research Method /Approach(Experimental / SLR / A case study)	Experimental method
Research Questions Address up	*Directly: RQ3* *Indirectly*: RQ1

the incremental approach, which makes solution-oriented results possible [41]. Agile models represent the complete set of incremental approaches used to transform the problem into a solution-oriented shape. Among the agile models, Scrum can be considered as the most stable and mature incremental approach model, later remodified in the form of review-scrum (R-Scrum) and IScrum [6], [9]. The term "incremental approach" is indirectly embedded in the classification of ECG features as reflected in the articles. These articles indicate that the classification of information is achieved systematically and can be used for further classification if so required. In respect to the traceability element, the incremental approach plays a vital role in model based ECG features classification that also delivers the flexibility component in the deep classification process [3]. The terminology of deep classification of ECG features indicates the normalized form of ECG elements that are useful in any subsequent investigation. Such terminology in model based ECG features classification map up with agile method model engineering that indicates the regressive approach followed in every operational activity [18], [21].

V. TAXONOMY

The research trend reflected in the literature highlights the facts and figures of different techniques of ECG feature classification by using state-of-the-art methodologies. According to our best knowledge, the exact root cause of the problems has yet to be determined. These problems come in many shapes, some of them more prominently highlighted in the articles than others such as the dependencies factor in ECG feature analysis, the hidden noise factor in ECG signal after noise filtration, undefined threshold value (may

TABLE 9. Scoring rate of selected articles.

		ARTICLE SCORING GENRATOR					
Reference	Paper Title	Assessor 1	Assessor 2	Assessor 3	Assessor 4	Assessor 5	Total Score
[3]	A Fuzzy Logic-Based System forEnhancing Scrum Method	1	0.5	0	0.5	1	3
[6]	Review-Scrum(R-Scrum) Introduction Of Model Driven Architecture (MDA) In Agile Methodology	0.5	0	1	1	1	3.5
[8]	Crowd-Sourced Annotation of ECG Signals Using Contextual Information	0.5	0.5	0.5	0	0.5	2
[9]	IScrum: An Improved Scrum Process Model	1	1	0	1	1	3.5
[10]	Cardiac anomalies in individuals with the 18q deletion syndrome;report of a child with Ebstein anomaly and review of the literature	1	0	0.5	0.5	0	2
[12]	ECG Signal Analysis Using Wavelet Transforms	1	1	0.5	1	0.5	4
[13]	Empirical mode decomposition based ECG enhancement and QRS detection	0.5	0.5	0.5	0	0.5	2
[14]	R-peak detection algorithm for ECG using double difference and RR interval processing	0	0.5	0.5	0.5	0	1.5
[15]	A combined algorithm for T-wave alternans qualitative detection and quantitative Measurement	0	0	0.5	0	1	1.5
[18]	Distributed data-driven platform for urgent decision making in cardiological ambulance control	1	0.5	0.5	0.5	1	3.5
[19]	The Definition of Intelligent Computer Aided Software Engineering (I-CASE) Tools	0.5	0.5	0.5	0.5	0.5	2.5
[20]	Classification of ECG signal during Atrial Fibrillation using Autoregressive modeling	1	0.5	0.5	1	1	4

TABLE 9. *(Continued.)* Scoring rate of selected articles.

[21]	Agile Modeling Method Engineering	0.5	1	0.5	0.5	1	3.5
[22]	MonAT: A Visual Web-based Tool to Profile Health Data Quality	0.5	0.5	0.5	0.5	1	3
[23]	Data-drivenWeb-based Intelligent Decision Support System for Infection Management at Point-Of-Care: Case-Based Reasoning Benefits and Limitations	1	0	1	0	1	3
[24]	Abstract Information Model for Geriatric Patient Treatment	0	0	0.5	0	0	0.5
[37]	Diagnosis of Cardiovascular Abnormalities From Compressed ECG: A Data Mining-Based Approach	0	0.5	0	0	1	1.5
[40]	DSCo: A Language Modeling Approach for Time Series Classification	0.5	0.5	1	0	1	3
[41]	Identifying the Contextual Relationship among the Agile adoption factors through Interpretive Structural Modeling	1	0.5	1	1	1	4.5

varies) for peak analysis in ECG, and the lacking state-of-the-art methodologies for error detection (traceability factor).

The most significant area of this study covers the critical observations that are made in respect to the selected articles. According to the scope of this study, our primary concern is to identify the classification issues of ECG features and deliver the most appropriate solution that reduces the problems related to the ECG feature classification. Its complexities are due to the involvement of features dependencies. The removal of those features dependencies constitutes a complicated process in every classification technique, and highlighting these dependencies plays a vital role in the classification of the different features in addition to the identification of anomalies. Parallel in-depth classification is regarded as the best possible solution meaning to highlight the maximum possible dependencies. In AF detection, those factors of heart rate variability (HRV) are highlighted that are involved in AF detection. In myocardial infarction (MI) detection are highlighted the factors responsible for premature ventricular contraction (PVC) which are involved directly or indirectly in the detection of MI (R peak analysis is helpful for the detection of T wave).

VI. FUTURE DIRECTIONS

The operational investigations of ECG analysis are likely to be continued given the fact that it involves highly complex scenarios. However, the reduction of these complexities is highly desirable for cardiologists and researchers. In the context of the above discussion, the following areas merit the most attention:

Multiple classifications of ECG in parallel processing under usage of MDE.

1. A development of a regressive model for broad classification of ECG features.
2. Reduction of complexities in the form of dependencies in the presence of noise factor in ECG signals.

VII. CONCLUSION

This study has investigated the core process of ECG classification based on different model oriented solutions. The reason for embedding the model-based classification is in order to ensure traceability, reusability, and maintainability. The aim of this study has been to identify optimal ways of fitting the different modular architecture as part of the ECG feature classification. In order to achieve this aim, the research problems have been defined in accordance with the research questions before seeking the answers to these research questions in-depth in the literature narrowed down to a collection of 41 articles directly or indirectly related to solution-oriented and model-oriented ECG features classification. The four primary databases have been used for the collection of these articles published between 2008 and 2017. The three different rectification processes have been implemented on these 41 articles and rectified the articles by title and abstract, eligibility criteria and quality assessment paradigm. The rectification process resulted in 11 articles that mapped up with the predefined research questions. These 11 articles delivered the answer to the question of how to fit the model classification in ECG features.

In the course of this study, we were able to make some critical observations concerning the gaps in this area of research primarily related to the classification process. Highlighting the dependencies constitutes the primary concern in the classification process since identifying these dependencies makes it possible to normalize the ECG signals. Similarly, other issues like hidden noise factor after the complete noise filtration process and lack of baseline threshold values for different peak analysis in ECG require additional research and improvements. Future research may be able to address these persisting concerns in the classification process. The issue of dependencies is expected to be resolved in the future by moving into the direction of parallel feature classification and the use of MDE, development of a regressive model for in-depth classification and normalization of the ECG signals.

APPENDIX A
See Table 8.

APPENDIX B
See Table 9.

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UZAIR IQBAL is currently pursuing the Ph.D. degree with the Faculty of Computer Science and Information Technology, University of Malaya, Kuala Lumpur, Malaysia. He is involved in the research project of feature analysis of ECG which is related to behavioral analysis of different cardiovascular diseases and anomalies in ECG.

TEH YING WAH received the B.Sc. and M.Sc. degrees from Oklahoma City University and the Ph.D. degree from the University of Malaya. He is currently an Associate Professor with the Information Science Department, Faculty of Computer Science and Information Technology, University of Malaya. His research interests include data mining and text mining.

MUHAMMAD HABIB UR REHMAN received the Ph.D. degree in mobile distributed analytic systems from the Faculty of Computer Science and Information Technology, University of Malaya, Kuala Lumpur, Malaysia. He is currently an Assistant Professor with the Department of Computer Sciences, National University of Computer and Emerging Sciences, Lahore, Pakistan.

QURAT-UL-AIN MASTOI is currently pursuing the Ph.D. degree with the Faculty of Computer Science and Information Technology, University of Malaya, Kuala Lumpur, Malaysia. Her research project is classification of premature ventricular contraction cardiac arrhythmia for different cardiovascular disease.

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