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Developing a Client Performance Evaluation Model using Machine Learning Methods for a Three-Stage Technology Incubation Process

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Abstract

Technology incubators, where new early-stage ventures accommodate in a supportive environment, are younger than 15 years of age in Iran. Nevertheless, it is necessary to localize the technology incubator models based on such parameters as culture, human resources, level of technology, and education system so as to meet an appropriate effectiveness. To achieve this goal, the present paper firstly introduces a three-stage incubation model considering special characteristics of the studied country. In this proposed model, the pre-incubation stage is the same as other currently used models but the incubation stage breaks down into two new stages namely technology incubation and technology development. The new model enhances market concentration and encourages incubator clients to finalize their products/services. This model has been successfully implemented in Kerman Technology Incubator and our experimental studies and evidences show the effectiveness of the proposed approach in improving the performance of the incubator. At the second phase, a machine learning evaluation model is developed with an aim to measure the incubator's client performance. This model utilizes the advantages of classification algorithms for mapping the business success factors into quality of client level. Hence, different classification methods are applied and their performances have been compared together. Results show the efficiency of the developed model in terms of accuracy.

Keywords: Start-up enterprise; Technology incubator; Three-stage incubation process; Quality of client; Performance evaluation model

Introduction

Technology incubator is a novel economic development structure whose main aim is to create wealth and growth of local economy through innovation and entrepreneurship culture promotion [1-3]. It provides a synergic and competitive innovation environment and accelerates the commercialization of technology results via growth of early ventures. In particular, the technology incubator acts as an intervenient between market and enterprise and intends to reduce business risk. It also raises the survival rate of start up by offering some value-added services and sharing facilities for graduates and researchers [3-6].

Technology incubator is a new concept in many developing countries and is fewer than 15 years old in Iran. Therefore, a serious effort was initiated by the ministry of Science, Research, and Technology through establishment of 20 ICT incubators nationwide in 2003, which has increased up to more than 100 general- and special-purpose technology incubators up to now. Although, technology incubator is a powerful structure to promote local economy and the level of people life, like other experiences transferred from developed countries into developing and under-developed regions of the world, it is essential to customize incubator models for each region according to culture, human resources, level of technology, and quality of education system in order to meet an appropriate performance. Accordingly, conducting a comprehensive assessment of incubator performance based on an effective evaluation system and applying necessary modifications on models and processes is highly desired. To gain this aim, a new three-stage incubation model was proposed instead of the common two-stage model so as to enhance the effectiveness of technology incubators. Firstly, with respect to this model, the incubation stage breaks down into technology incubation stage and technology development stage, with an aim to increase market concentration. Secondly, an evaluation model based on artificial intelligence algorithms was developed to measure the performance of incubator clients. This model maps such relevant business parameters into the level of quality of client (QoC). By doing so, different classification methods were utilized and their performances were compared with one another.

To make process modifications, a short-term training course was added to applicants selection process, as a win-win game for both applicants and incubator leadership, which on one hand familiarizes the applicants with hidden aspects of business, and on the other hand enables the incubator leadership to find the most determined and qualified applicants. This is advantageous especially in Kerman province where entrepreneurship culture is not institutionalized and people often prefer to get employed by government. Also, the idea-oriented selection strategy was substituted with team-oriented selection strategy which causes an increase in survival rate of clients and consequently enhances the incubator performance. The main reason was that a coherent team of professionals will find a success path through creating new ideas even if the primary idea loses its advantages.

In the field of developing technology incubator evaluating systems, several studies have been conducted. However, most of these efforts are focused on incubator performance instead of on evaluating the accommodated clients. Moreover, there seems to be very few researches in the context of developing incubator client evaluation models using machine learning techniques. Without taking into account the presence of the enterprise in technology incubator, in a multi-criteria new venture evaluation method is proposed with the aim of getting objective answers about the effectiveness of optimal new

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venture to fund [7]. Scholars in develop a management performance evaluation model which utilizes financial and non-financial factors for Korean construction firms [8]. In authors identify the enabling factors influencing the success of university business incubators with respect to specific internal resources, and to explore the priority of these factors [9]. Authors in apply a multi-criteria decision making model to identify new technology business firms for venture capitalists [10]. In, a balanced score card (BSC) is proposed which includes non-financial aspects related to performance evaluation in long-term [11]. Authors in studied company performance in four archetypal incubators and categorizes performance measures in five categories [12]. They find there are significant differences in three of the five performance categories among incubator types. In a hierarchical multi-criteria method has been proposed to study the effectiveness of marketing strategies on enterprise performance [13]. Also, in fuzzy synthesis judge (FSJ) is applied to set up a model of performance evaluation criterion for assessing the quality of enterprise outsourcing management [14].

The rest of the paper is organized as follows: we describe the common technology incubator model including the applicant selection, supporting, and service process; besides, the Kerman Technology Incubator (KTI) is briefly introduced in this section. The three-stage technology model will be introduced and the efficiency of the proposed model is compared with the common two-stage incubator model. The common incubator evaluation and monitoring process and an intelligent evaluation model is developed to measure the performance of incubator clients by exploiting some well-known classification algorithms. Different experiments are conducted using WEKA and the performance of the models is compared with one another. Section 6 concludes the paper.

The Common Technology Incubator Model

Technology incubator is an optimized supportive infrastructure for launching successful start-up enterprises established by entrepreneurs, especially university graduates. Accordingly, technology incubators play a vital role in accelerating the growth of start-up ventures along the way from idea to market. This is possible by offering some value-added services and sharing the facilities for graduates and researchers. The outcome of incubator will then have the potential to create jobs, commercialize new technologies, and resultantly strengthen the local and national economies [3,6,15].

An overall input-output model of technology incubator is depicted in Figure 1. As shown, the inputs of model can fall into one of the following categories:

1. Start-up enterprises
2. University graduates in the form of specialist groups
3. Research cores

On the other hand, the outputs of the model will be:

1. Successful enterprises that are well-established ones.
2. Failure clients which unable to achieve the desired objectives.
3. Rejected candidates who do not meet the admission requirements.

With respect to this model, technical and business advisors and also service-based companies assist the incubator leadership team to gain the desired objectives. In this regard, the monitoring and evaluation system, technology council, business plan, regulations, and legal documents can be exploited. Therefore, an adequate coordination and effective relation between the incubator leadership team and other components is essential.

Figure 2 illustrates the technology incubator model in more detail which contains four different steps including

1. Training,
2. Admissions,
3. Accommodation and support, and
4. Graduations.

As the first step of incubation process, candidates participate in a training course to learn more about the principles of business and also get familiar with technology incubator programs. In this step, some candidates may refuse to continue and hence become rejected. At the next step, the candidate's business plan will be evaluated and checked in such aspects as management team, marketing strategy, funding approach, risk strategy, etc. The accepted candidates will be then accommodated in the incubator and are supported by value-added services. The last step in incubator process is the graduation phase

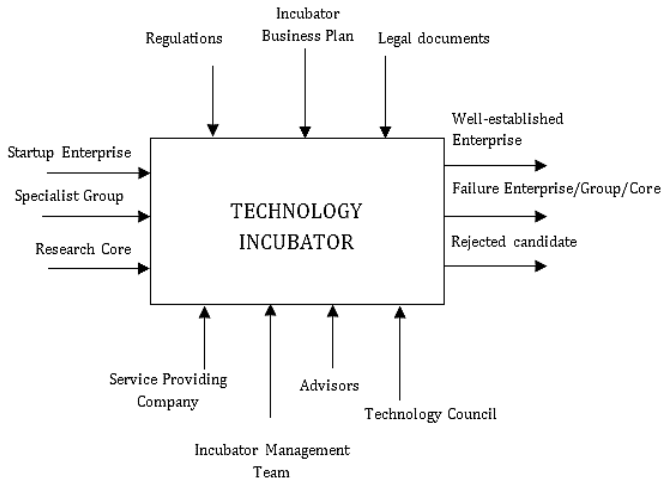


Figure 1: The overall technology incubator model.

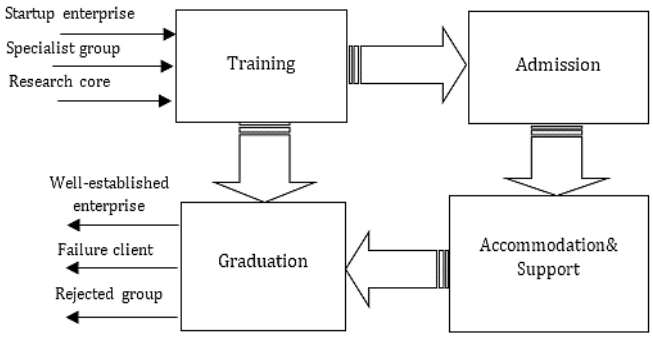


Figure 2: Technology incubator model in more detail.

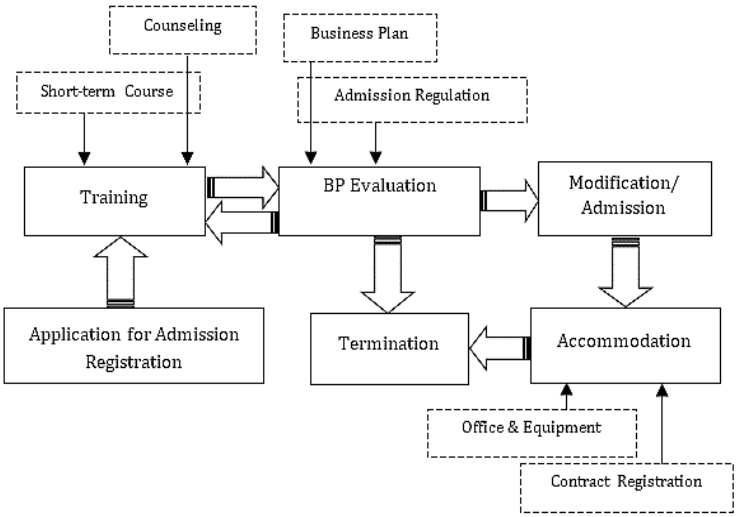


Figure 3: The applicant selection process.

while both successful and failed clients will carry out accounting and then leave the technology incubator to continue their activities outside the incubator.

Applicant selection

In the incubation process, the first step is the selection of good candidates who are able to start a promising and successful business. It is a key point that anyone who has a good idea may not be a qualified leader for a risky business. In this respect, the term "good candidate" can be interpreted in various ways such as:

1. An experienced team with the ability to engage in a risky business.
2. An innovative idea with an attractive and clearly-defined market.
3. A specialist group with the ability to implement an idea and develop a new product.

In order to evaluate the attractiveness of an idea, different aspects of business should be taken into consideration, including sales and profit potential, regulatory and social constraints, competitive environment, rate of production, technological obsolescence, risk distribution, and the scope of opportunities [15,16].

Figure 3 depicts the model of applicant selection process in technology incubators. At first step, applicants must register the application for admission. As previously stated, a training course is held for applicants to familiarize them with the basic concepts of business and the benefits of a business plan (BP). The applicant's BP will, then, be evaluated by experts to determine if the applicant should be approved for acceptance or not; after that, some modifications will be made if necessary. The last step is contract registration and providing an office with some primary equipment. Although some BPs may be rejected in this step, the applicants can register a new BP if they are going to be supported.

Experience 1: A short-term business training course is held in Kerman Technology Incubator during the applicant selection process entitled "Principles of launching a knowledge-based enterprise". This course helps candidates to get familiar with the principles of innovative businesses including idea processing and promotion, team-working skills, effective negotiation techniques, marketing strategies, and so on. This course is free for all applicants and is held four times a year on average. Also, the effectiveness of the course gets evaluated after each session through asking some questions that provide feedback. This course also helps leadership team to classify the promising applicants accurately. The syllabus for the course is as follows:

- Selection of a good idea
- Idea processing
- Leadership characteristics
- Basic principles of marketing
- Business risks
- Financing in start-ups
- Writing a good business plan.

After taking part in the training course, the applicants are expected to be able to answer some important questions:

- What are the characteristics of a well-processed innovative idea?
- What should an entrepreneur carry out before implementing an idea?
- Who can be a leader of business and what are her/his characteristics?
- What are team-working skills?
- What is business risk and how can we reduce it?
- What is the role of an efficient business plan in business success?

As mentioned earlier, the effect of the course on applicant's decision is being studied at the KTI by asking some related questions. Based on the results gathered and also analyzed from nearly 650 applicants' opinions, more than 90% of the candidates believe that the course helped them to take a better decision. Nevertheless, the results show that a significant number of candidates (approximately 85%) prefer to have a government job instead of engaging in risky business ventures. Various reasons can be considered for this, the most outstanding of which being related to the region's culture can be summarized as "A small but permanent income is far better than a large but impermanent one!". According to this conventional wisdom, a hand-to-mouth income is still often more attractive in this region.

Experience 2: In the early years of the KTI establishment, having an innovative idea was the most important admission criteria in applicant selection process. Conforming to this view, the idea-oriented selection was the dominant strategy. After studying the reasons of client failure, it was concluded that the implementation of an idea is not an objective by itself: it is rather a reason to achieve the major goal, i.e., launching and developing a successful business. Therefore, the incubator strategy changed from idea-oriented to team-oriented selection. Accordingly, if one idea loses its competitive advantage due to market failure, technological problems, or material and instrument lacks, still the team of professionals will create new ideas in accordance with their business mission. This avoids business failure and enhances the business survival chance.

Supporting and services

Technology incubator is a service-oriented organization. Hence, after the client selection phase, the main obligation of the incubator is started, that is supporting the new start-up enterprises through a comprehensive range of value-added, secure, flexible, and well-equipped physical-space services [17-20].

1. General services refer to well-equipped office space, secretarial and reception services, mail handling, fax and copying, book keeping, conference facilities, session room, furniture, restaurant, and other physical infrastructures.
2. Scientific services refer to Internet, laboratory, scientific databases, local-area network, web and email hosting, library, and information centers.
3. Counseling and training services refer to business advice and training courses in different fields such as marketing, financing, management, commercial laws, business plan, and so on.
4. Financing and marketing services refer to funding, accounting, banking, national and overseas trade fairs and exhibitions, advertising, intellectual property, and patent registration.

It should be noted that in each stage of incubation process the priority of services should be conformed to the enterprises' growth stages. For instance, a new accommodated client often requires office space and training materials while older clients need marketing and advertising services. Figure 4 depicts the incubator's supporting and service process. As shown, after evaluating the short/medium-term executive program and adopting it with the client's BP and regulations, the client will have access to the desired services. The incubator services may be provided by service-based companies according to a specified agreement. Finally, in the accounting step, the services fee will be paid by the client.

Training courses should be carefully planned in technology

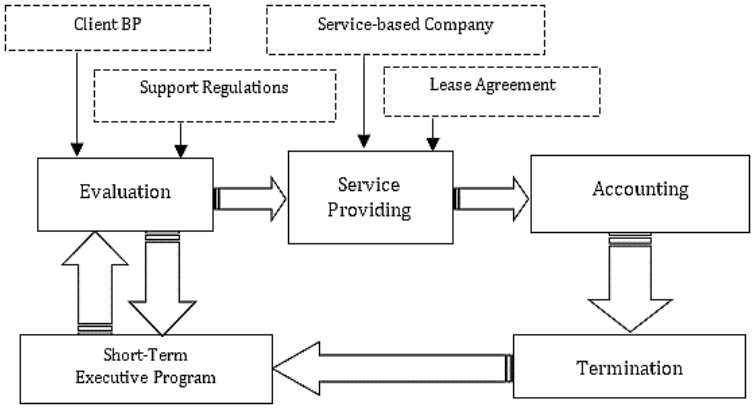


Figure 4: The supporting and service process.

incubators due to lack of familiarity of university graduates with business concepts. The training program should contain some short-term training courses including the principles of advertising, marketing, management, accounting, team-working, business risks, etc. It is worth to emphasize that in early years of accommodation, the training courses are often general and as the enterprise grows up, they should become more and more specialized

Kerman technology incubator- a brief introduction: Kerman province with a population close to 3,000,000 people is located in the south eastern Iran. More than 160,000 students are studying in this province and nearly 25,000 students graduate every year. With regard to the rapid growth of university graduates seeking jobs and based on the potentials of the region, the KTI was launched by the International Center for Science, Technology & Environmental Sciences (ICST) in 2003. There are more than 40 offices to accommodate the start-up enterprises. According to environmental conditions, human resources, and regional capacities, the Kerman Technology Incubator supports start-up clients in a variety of fields including information and communication technology (ICT), nanotechnology, agriculture, biotechnology, mineral process, and renewable energies. In recent years, in accordance with the development policies, others buildings have been provided to accommodate more than 150 clients. Figure 5 shows the number of clients that have been supported by the KTI since 2003.

The Technology Incubator Model: A Three Stage Model

The main stage of technology incubator is incubation with duration of 3 to 5 years. During this period, the incubator helps early-stage ventures to transform their ideas into products or services [19-23]. Due to lack of business experience, the pre-incubation stage is defined in technology incubator to help clients for satisfying the requirement of incubation stage. In particular, the pre-incubation stage is an interface between university and technology incubator. In this stage with duration of 6 to 9 months, the clients ought to develop an innovative idea and define market segmentation prior to being registered as a company.

Figure 6 depicts the common two-stage process that has been set up in most technology incubators. As shown, the pre-incubation stage is for those candidates who do not have enough business experience; however, the competent candidates having already registered a legal company can neglect this stage and directly go forward to incubation stage. The graduated pre-incubation clients who meet the incubator criteria would be the input of the incubation stage. As mentioned earlier, the most common promotion criteria are developing the idea, identifying the market, building a team, and registering the company. After that, the clients usually spend between 3 to 5 years in the incubation stage depending on type of business. In this stage, clients should finalize their products/services and get ready to enter to market.

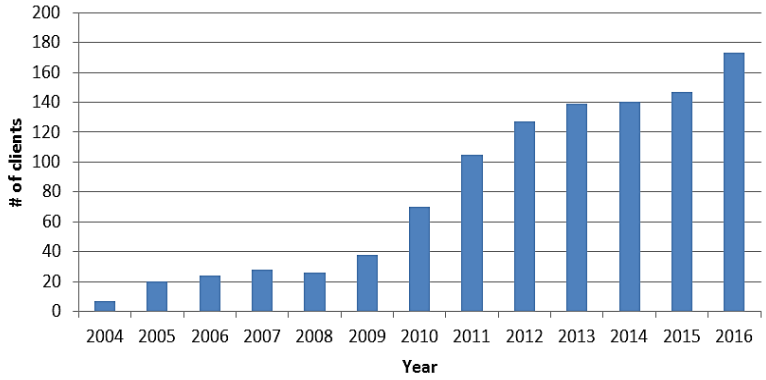
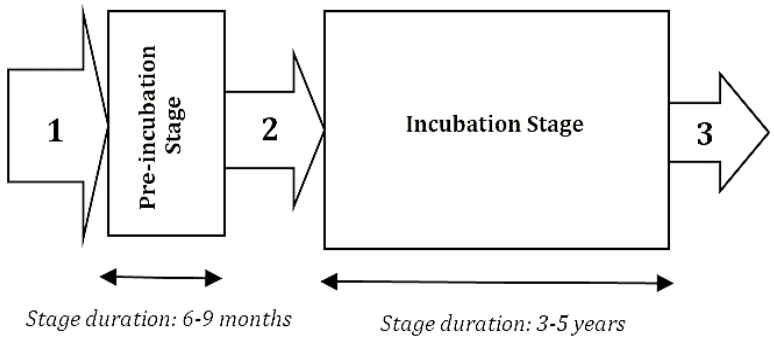


Figure 5: Number of clients in Kerman technology incubator (KTI).



1: *The incubator candidates, without any business experience*
2: *The pre-incubation graduates, new established enterprises*
3: *The established enterprises, ready to accommodate in STP?*

Figure 6: The 2-stage incubator model.

Eventually, the clients will graduate from the technology incubator and may afterwards be accepted in Science and Technology Park (STP) [19,22].

From the perspective of business life cycle and in accordance with technology incubator concepts, the enterprise development process can be defined in four different phases, namely the start-up, growth, expansion, and maturity [24,25]. In the start-up phase, clients often attempt to complete their employees, identify their target market and costumers, provide initial financial resources, and supply materials, instruments, and technological requirements. In the growth phase, the special emphasis is on implementing and testing the product, performing a limited marketing to get customer feedbacks and getting product qualifications. During the expansion phase, enterprise should pay particular attention to product/service marketing and advertising. Most activities consist of taking part in national and international exhibitions, finding the distribution channels, securing intellectual property protection, and obtaining venture capital funds, banking facilities, and other funding resources. The last phase is maturity in which the enterprise completes the incubation process and becomes well-established. In this case, some activities such as brand promotion, industry upgrading, products development, and global investment will be conducted.

Attention to the enterprise life cycle and matching it with the incubator process is of utmost significance; an effective incubator must be able to reconcile the enterprise development process with incubator process to lead efficient service provision. To attain this objective, some change should be applied to the commonly-used incubator model. On this basis, we proposed a three-stage technology incubator model, in which the pre-incubation stage is the same as prior but the incubation process is divided into two new stages namely, technology incubation and technology development stages to replace the growth and expansion stages, respectively. In the end, the maturity phase can be considered for qualified clients who intend to continue their activities in Science and Technology Park. Figure 7 shows the enterprise development stages and their relationship with technology incubator process.

Similar to the expansion stage, the clients in technology development stage should concentrate on marketing and advertising of products/services, access to distribution channels, funding resources, etc. This stimulates the clients to finalize their products and services implementation in incubation stage. In other words, the technology development stage can be defined as a preliminary stage similar to the incubator's pre-incubation stage for clients who are deciding to accommodate in STP.

Figure 8 illustrates the three-stage technology incubator model. Here again, as in the two-stage model, the candidates with no business

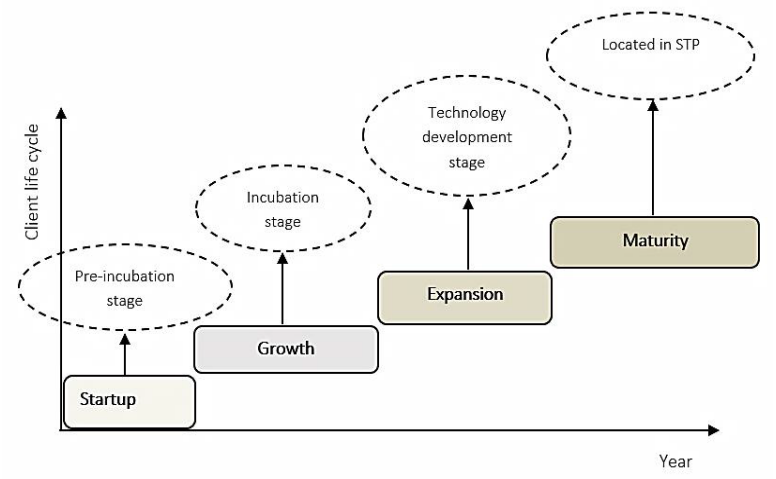
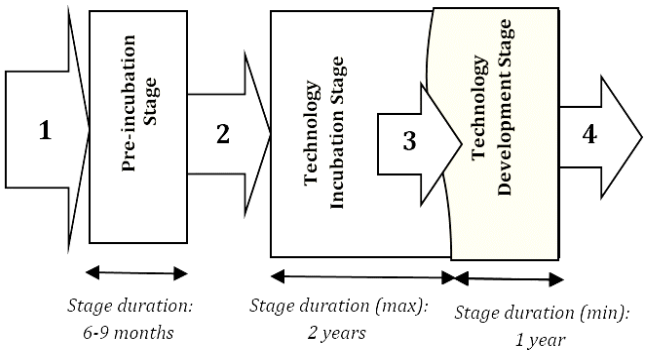


Figure 7: Adopting enterprise development process with incubator process.



1: *The incubator candidates, without any business experience*
2: *The pre-incubation graduates, new established enterprises*
3: *Technology incubation graduates, ready for marketing*
4: *The established enterprises, ready to accommodate in STP?*

Figure 8: The 3-Stage incubator model.

experience are represented as inputs of pre-incubation stage. Regarding the performance report, some of the clients pass the pre-incubation stage after 6 to 9 months to technology incubation stage. Maximum after 2 years, the clients will be ready for marketing and advertising if they acquire the main objectives of this stage, i.e., implementation and testing of the product. The outcome of the technology incubation stage will be the technology development stage candidates where the affirmation is the marketing and selling of their products and services.

It is evident that some clients in each stage are not able to obtain the next stage promotion criteria, hence as shown in the figure, the arrows will be narrower from left to right due to the reducing number of clients at each stage. A key point in incubator process is the limited but floating duration of each stage. Accordingly, the maximum duration for pre-incubation and incubation phases can be considered as 9 months and 2 years, respectively, whereas the minimum duration for technology development stage will be 1 year according to the overall incubation duration. It should be emphasized again that each incubation stage should consist of own exit criteria and graduation policies to have a correct understanding of the incubator clients performance.

Client Performance Evaluation Model

One of the main characteristics of technology incubators is their continuous tracking and assessing of their client's progress in order to have an accurate view of their health. A good evaluation system must be able to determine whether businesses are still in operation or not. This will cause higher survival rate of clients and consequently improve the incubator's performance [23,25,26]. An incubator should monitor and evaluate the clients to find their weaknesses, needs, threats, and so forth. On the other hand, the outcome of an incubator evaluation system must be a helpful solution and a source for valuable advices, known as supervising for better advising strategy. The establishment of an efficient monitoring and evaluation system helps the incubator to know whether the clients are operating according to business plan and the executive programs to gain their desired goals or not; also, clients' problems can be recognized and initiatives can be taken to find solutions; moreover, client will have more competence for higher level promotion or graduation; finally, the quality of incubator services and their impact on client growth can be assessed.

The common monitoring and evaluation process in most existing technology incubators is illustrated in Figure 9. According to this process, each client should submit an activity report during particular periods of time; then, the report will be matched with the corresponding business plan and the assessment regulations to measure the program progress of the client in the fields of scientific, technological, marketing, etc. As the next step, the obtained results will be compared with the expected results to calculate the deviation from targets. In this step, the client advisor may give some advice for modification and/or wrong way correction.

Figure 10 focuses on the overall client evaluation model as the main part of monitoring and evaluation process. The inputs of the model are those parameters related to the progress of the clients, while the outputs correspond to the quality level of the client. For this, we defined the Quality of Client (QoC) metric which categorizes the performance of each client in four level from poor to excellent based on various performance indicators [27,28]. In order to develop desired model, a two-step process is performed. At the first step, the desired model is produced based on a subset of original dataset namely training dataset. For this, a feature extractor is used to convert input values to features. After future size reduction, pairs of feature sets and labels are utilized to derive a machine learning model. In this phase the parameters of the trained model is determined. At the prediction phase, the derived model predicts the category of a subset of unseen samples namely test data.

The first part of model is to create a proper dataset as the prerequisite of the system. Then the proper features that have the highest correlation with QoC are identified. Feature vector may include a number of irrelevant features that causes the complexity of the model. Applying feature vector reduction techniques can improve the efficiency and reduce the complexity of the final model. In the final stage of the mentioned process, the classification is performed to determine the quality level of incubator clients.

These client performance indicators can be classified in four main classes as follows:

- Scientific and Technological (SUBSET I) indicator is related to idea implementation, developing the new ideas, having competitive advantages, and so on.
- Marketing (SUBSET II) indicator refers to selling the products and services, gross revenues, the number of investors and grants a business received, the amount of money the business has borrowed, taking part in national and overseas exhibition, and so on.
- Organizational (SUBSET III) indicator refers to how the job tasks are divided including the management team, the number of advisors, the number of full-time and part-time workers, and so on.

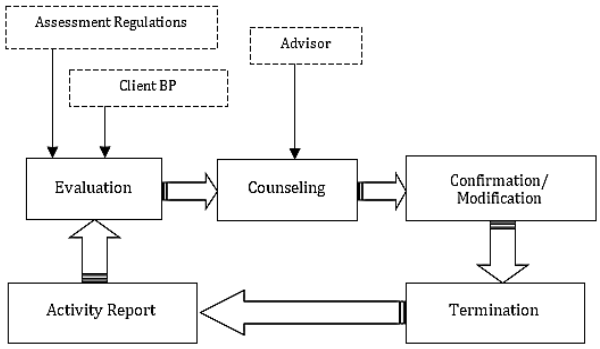


Figure 9: The monitoring and evaluation Process.

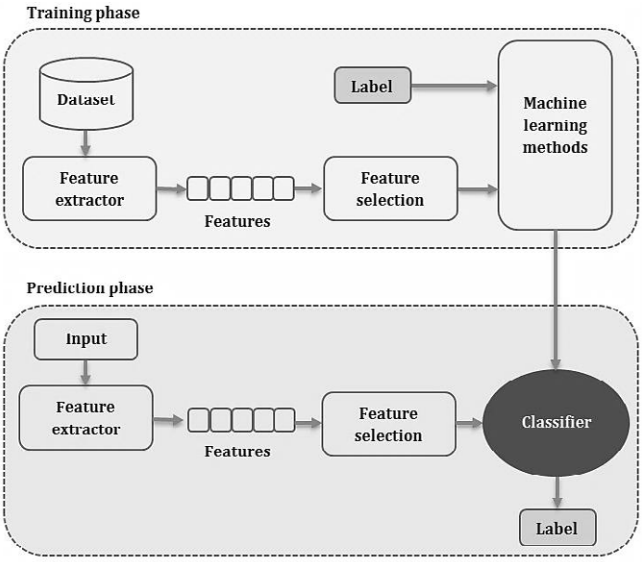


Figure 10: The overall quality of client evaluation model.

- General (SUBSET-IV) indicator refers to following the laws and rules, presenting the activity reports, participating in general incubator programs, and so on.

According to the above indicators, Table 1 summarizes the most important parameters utilized in the present study to derive performance evaluation model. For each parameter, a maximum point was considered and also to comply with concepts of developing an intelligent model, a feature number (column 2) was assigned to each factor.

According to QoC, the excellent quality is related to qualified clients, with success in implementing the ideas, organizing the enterprise structure, entry to market and having effective relation with various components of incubator. The good quality corresponds to high quality clients with minor weaknesses in some fields, especially in marketing. The medium quality corresponds to clients who are successful in idea implementation but often have shortcomings in organizing and marketing. For poor level, the client has failed almost in all fields. One of the advantages of performance evaluation model is how to deal with each level of client quality and how to solve their problems especially for good and medium levels.

Classification is a supervised learning method which assign the observation i.e., features of a collection of data to a predefined category. In this study, various types of classification techniques are utilized in two general categories namely individual and ensemble models. The ensemble learning methods operate based on this principle that the combining the predictions of a group of classifiers is often better than individual models. Accordingly, a series of base learner is constructed and then combined in various ways, such as voting and weighted averaging with the aim of improving accuracy and reducing the error rate. The ensemble learning refers to an area of interest in machine learning which operate based on that the combining the predictions of a group of base classifiers. The prediction of each individual model is combined in some way i.e., majority voting to classify unseen samples. There are different techniques to construct ensemble models. For example, bagging (bootstrap aggregating), boosting, and stacking [29] are the most common ensemble methods which operate by invoking a base learning algorithm many times with different training dataset. In this study, the tree different ensemble classifiers are used i.e., Bagging, Adaboost and Random forest classifiers.

Feature	Parameter	Maximum points	Indicator
F1	Idea implementation	40	Scientific and technological
F2	Development plan	35	
F3	Competitive Advantage	35	
F4	Patent registration	15	
F5	Membership in the international scientific community	10	
F6	Participating in training courses	15	
F7	Number of contracts	45	Marketing
F8	Product/service sales volume	35	
F9	Marketing plan	25	
F10	Financial plan	20	
F11	Sales promotion program	15	
F12	Patent valuation	15	
F13	Financial report	15	
F14	Organization structure	25	Organizational
F15	Strategic plan	30	
F16	Professional human resources	20	
F17	Specialized consultants	15	
F18	Key human resource	15	
F19	Administrative system and archive	15	
F20	following the labor and insurance regulations	10	
F21	following the incubator regulations and rules	10	General
F22	Interaction with incubator's authorities	10	
F23	Cooperation with other clients	15	
F24	Continuous reporting	15	

Table 1: Quality of client parameters.

Ordinary classifiers

1. NB: Naïve Bayes classifier
2. RPT: Reduces Error Pruning (REP) Tree classifier

3. BNN: Back propagation Neural Network classifier
4. SMO: Support vector classifiers by Sequential Minimal Optimization algorithm
5. FNN: Fuzzy k-Nearest Neighbors classifier.

Ensemble classifiers

1. BAG: Bootstrap Aggregating (Bagging) classifier
2. ADB: Adaptive Boosting classifier
3. RF: Random Forest classifier.

In order to compare the models, total accuracy measures (in percent) was employed which can be calculated using eqn. (1) [30]. In all cases, the accuracy was assessed through 10-fold Cross Validation (10 CV); in this method, data is divided into ten parts (i.e., folds) and in each iteration; nine of them are utilized for training the model while the 10th one is used for test. This process is then repeated ten times so that in each time one of the ten folds is used as the test data. Finally the average of errors over test data is used as a measure of the model performance [31].

$$\text{Total Accuracy}(\%) = \frac{\text{Correctly Classified Instances}}{\text{Total Number of Instances}} \quad (1)$$

In order to reduce the complexity of model, different collation-based feature selection techniques are used namely *Best First, Linear Forward Selection*, Genetic Search and PSO Search. For this the *Cfssubseteval attribute* evaluator in Weka is used [32] which evaluates the worth of a subset of attributes by considering the individual predictive ability of each feature along with the degree of redundancy between them [32]. In order to rank the features, the ranker feature selection technique is also used which exploits the Weka I*nfoGainAttributeEval* evaluator. This evaluates the worth of an attribute by measuring the information gain with respect class [32].

Experimental Results and Discussion

The process of developing an evaluation model includes different steps. The first step is data gathering which is utilized for creating training and test dataset. In this study, the data was collected from the performance of the three different incubator clients during a period of 10 years. In order to prepare datasets, we first provided a questionnaire and then ask the incubators expert to classify clients into four different classes from poor to excellent without consideration of score of each indicator. After that, the expert should fill the score of each indicator based on client activity reports and other related documents. Table 2 summarizes the specifications of three datasets including the number of samples and the frequency of each class.

At the next step, pre-processing methods should be applied which eliminates the out-of-range values, missing values, and so on. One of the most important steps namely the feature selection is then conducted to reduce the number of features and consequently reduce the complexity of the derived models. After that, a suitable classification method is used to categorize the quality level of each client in different classes. As mentioned earlier, for feature selection and classification, an open-source tool, WEKA, was used. As the last step, the comparison of the results is performed.

Feature selection

The result of applying four different correlation-based feature selection methods is summarized in Table 3. As shown, the number of features reduced from 24 to 7 (minimum) and 12 (maximum) due to applying different methods. In the case of dataset I, the (F1,F7,F8,F12,F14) are selected by both feature selection methods. In this case, F12, F13 and F16 are selected by 3 out of 4 feature selectors. For dataset II, the common features between four desired methods are (F1, F7, F8, F17). The F2 and F13 are selected by the most feature selectors. Finally, the (F1, F7, F8, F9, F13, F20) are selected by all features selection method in the case of dataset III. In this case, F24 is selected by 3 feature selectors. As it is clear the (F1, F7, F8) are common features between all datasets. These features are related to idea implementation, number of contracts, product/service sales volume.

Feature extraction

In addition to feature selection methods, two different feature extraction methods also utilized namely Principal component analysis

Data set	Number of features	Number of samples			
		Class 1	Class 2	Class 3	Class 4
Data set I	24	130			
		17	39	33	41
Data set II		172			
		28	38	42	64
Data set III		205			
		30 42		53	80

Table 2: Three Data set specifications.

Feature selection	Selected features					
	Data set I	No.	Data set II	No.	Data set III	No.
Best First	F1, F7, F8, F9, F11, F12, F13, F14, F20	9	F1, F2, F7, F8, F9, F14, F15, F17, F20	9	F1, F7, F8, F9, F10, F13, F14, F15, F20	9
Genetic search	F1, F7, F8, F9, F11, F12, F13, F14, F16, F24	10	F1, F2, F7, F8, F9, F13, F14, F15, F17, F19	10	F1, F2, F7, F8, F9, F10, F13, F14, F15, F19, F20, F24	12
Linear Forward Selection	F1, F3, F6, F7, F8, F11, F14, F23, F22	9	F1, F3, F7, F8, F17, F21, F22	7	F1, F3, F7, F8, F19, F20, F22, F24	8
PSO Search	F1, F3, F7, F8, F12, F13, F14, F16, F24	9	F1, F2, F7, F8, F17, F18, F24	7	F1, F3, F4, F7, F8, F20, F22, F24	8

Table 3: Applying different feature-selection methods.

(PCA) and Linear Discriminant Analysis (LDA). Both LDA and PCA are linear transformation techniques and have been widely applied in the area of computer science. Table 4 depicts the results of applying two different feature extraction methods. As shown, the reduction of feature size is 75% (24 to 6) on average for three different datasets.

Ranking the features

In order to rank the features, the ranker feature selection technique, implemented in Weka, is employed. This method utilizes the *InfoGainAttributeEval* evaluator which evaluates the worth of an attribute by measuring the information gain with respect class. Figure 11 depicts the average rank of each feature for three different datasets. The results are obtained based on 10-fold cross validation method. The red bar illustrates the average rank of each feature on three datasets. According to ranker method, the F8, F7, F9, F15, F2, F14 are the most important features in comparison with other ones. These features are related to product/service sale volume, number of contracts, marketing plan, strategic plan, and development plan and organization structure, respectively. In contrast, the F4, F5, and F24 related to patents registration, membership in international scientific and continues reporting are the least important features.

Comparison of classification model performance on three datasets: In this section, we compare the effect of different classification methods in three cases; without feature selection, with feature selection and with feature extraction. Figure 12 illustrates the total accuracy (%) of different classification model for these cases. With consideration the average accuracy on three datasets (red bar) and comparing the results, it would be clear that in the all cases (expect LDA) applying the feature reduction algorithms showed that employing the feature size reduction methods on one side reduces the complexity of the derived models and on other side enhances the performance of the models. Accordingly, it can be concluded that the most additional and irrelevant features have eliminated by above reduction techniques.

Results show that in the case of no feature selection, the SMO classifier with average accuracy near 77% outperforms other methods. However, the difference with other methods (except ADT) in not significant. In the case of feature size reduction, for Best First, Genetic Search and LDA, the NB has higher performance against other methods. In contrast, for Linear Forward Selection, PSO Search and PCA, the BAG classifier outperforms others. Figure 13 depicts the average of accuracy on different classifiers for each dataset. Also, average accuracy on three datasets is shown with red bar (Table 5). As shown, the Linear Forward Selection yields the most accurate models on average in comparison with other feature reduction methods. However, the results of Best First, Genetic Search and PCA are near to this method.

Effect of subset of features to the performance: In this section, we study the effect of feature subsets (SUBSET I, SUBSET II, SUBSET III, and SUBSET IV) on the performance of classification models for three different datasets. Figure 14 summarizes the average accuracy for each subset of datasets. In this case, the results are obtained using 10 fold cross validation method. As shown, the SUBSET II related to market indicator is the most important indicator. In contrast the general indicator (SUBSET IV) yields less accurate classifiers in comparison with others.

Concluding Remarks and Recommendations

This study introduced an effort made at the Kerman Technology Incubator to localize a model and its processes. To do so, as the first step, some modifications were applied in common processes. Next, to be more adaptive with enterprise development life cycle and also to stimulate the clients to finalize their products, a new stage called technology development stage was defined. This stage concentrates on marketing and can be considered as a preliminary stage similar to incubator pre-incubation stage for clients who are deciding to accommodate in STPs. This modified model has been successfully examined in Kerman Technology Incubator and evidences show the effectiveness of the proposed model on incubator performance. Furthermore, a machine learning evaluation model was developed as

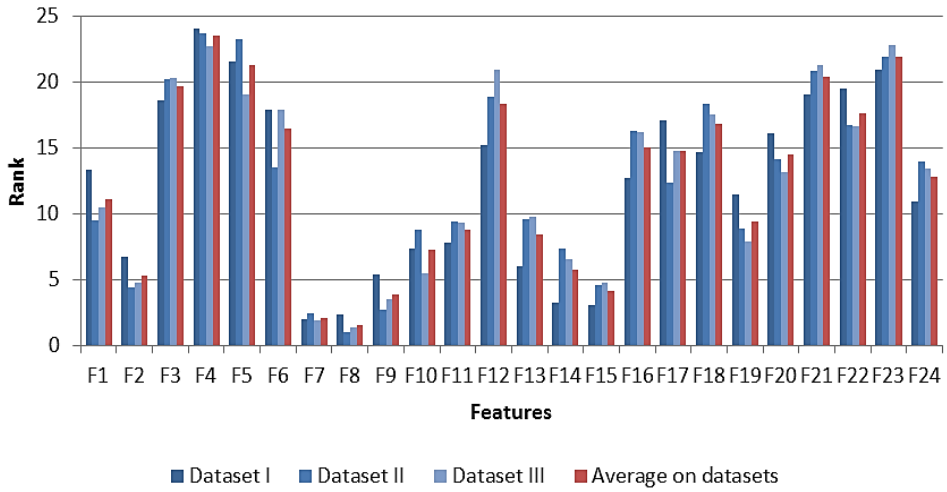


Figure 11: Averaging ranking of features (10 fold cross-validation).

Feature extraction method	No. of extracted features		
	Data set I	Data set II	Data set III
PCA	5	6	7
LDA			

Table 4: Applying different feature extraction methods.

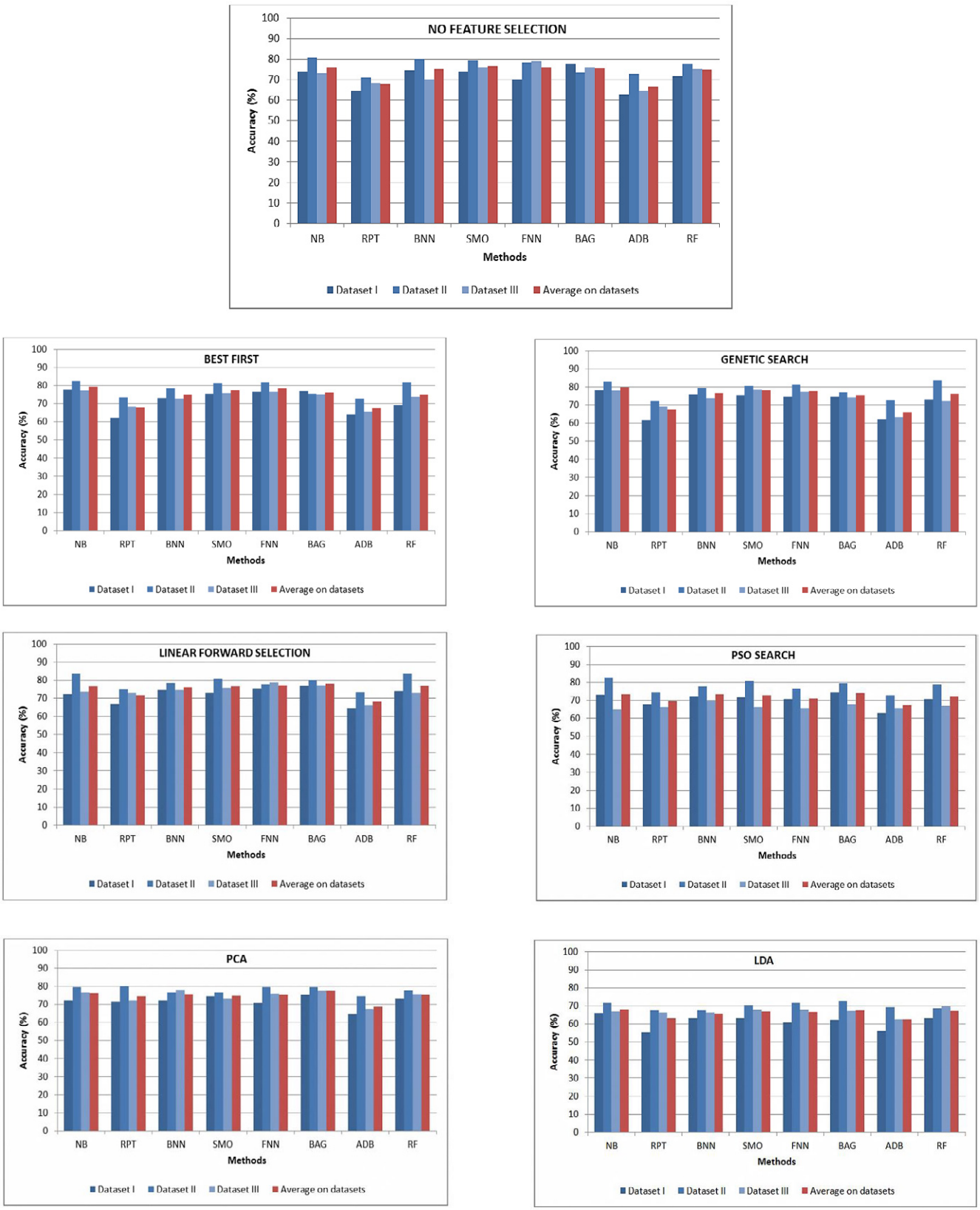


Figure 12: Comparing the effect of different classification methods in three cases; without feature selection, with feature selection and feature extraction.

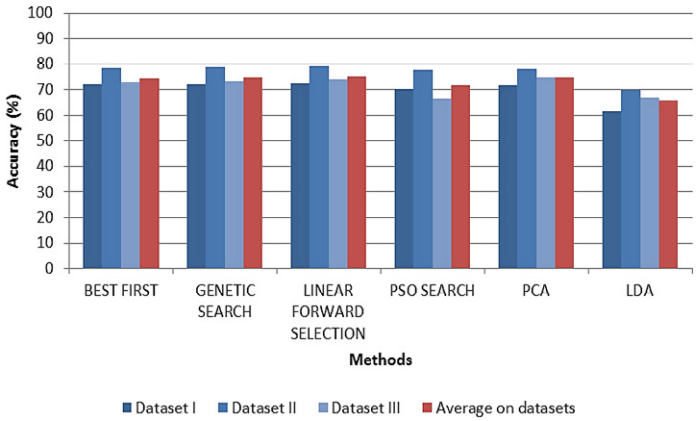
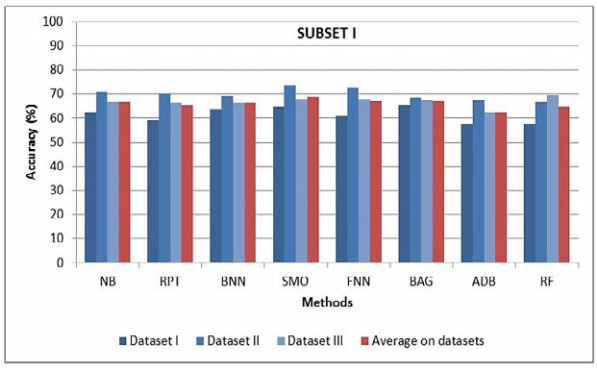
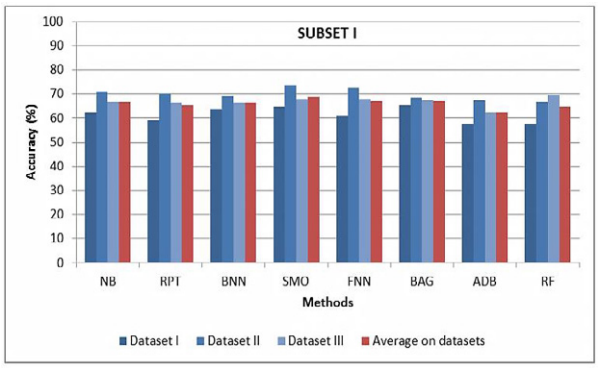
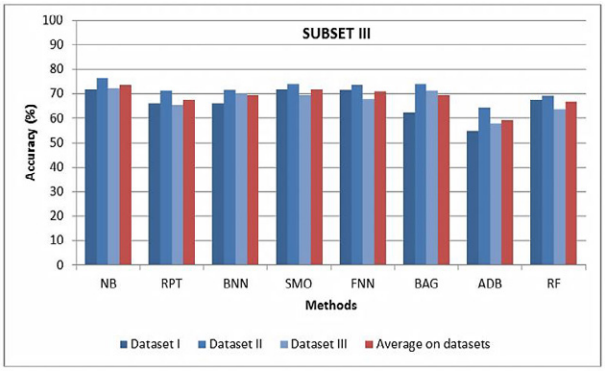
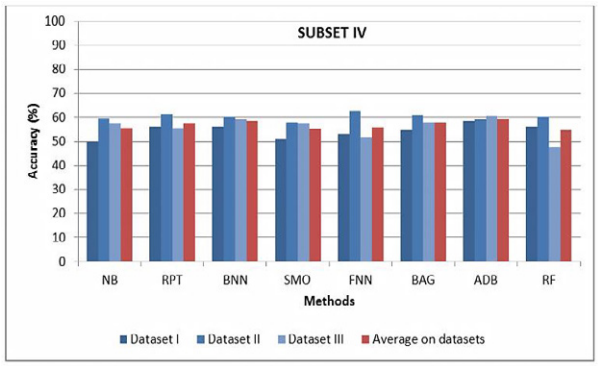


Figure 13: Average accuracy of different classifiers for each dataset based on different feature reduction methods.









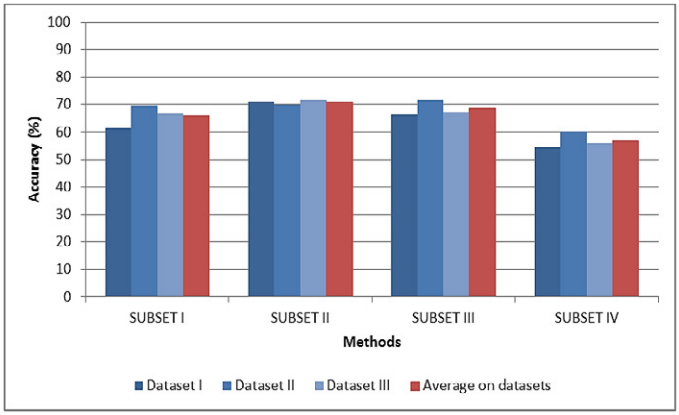


Figure 14: Average accuracy for each subset of datasets.

Feature reduction	Best first	Genetic search	Linear forward selection	PSO search	PCA	LDA
Accuracy (%)	74.49	74.75	75.12	71.73	74.84	65.97

Table 5: The average accuracy of classifiers on three Data sets by applying different feature reduction methods.

a part of incubation process to categorize the client performance. This model exploits the advantages of classification and feature-selection algorithms, and categorizes the incubator clients in different quality levels based on a variety of business indicators. In order to study the efficiency of classifiers, three different dataset are collected based on incubator experts opinion and client activity reports. Applying different feature selection techniques show that the (F1, F7 and F8) features are selected by all feature selection methods on all three datasets. These features are related to idea implementation, number of contracts, product/service sales volume. Also, the results show that the Linear Forward Selection yields the most accurate models on average in comparison with other feature reduction methods. In addition, the study of the feature subsets effect on the performance of classification models shows the market indicator is the most important indicator in comparison others.

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