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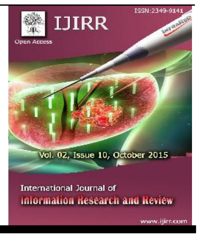

Review Article

A REVIEW ON APPROACHES TO OPTIMIZE THE REQUIREMENT ELICITATION PROCESS

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ABSTRACT

Requirements elicitation is defined as a process of collecting the requirements of a system from users, customers and other stakeholders and also referred as requirement gathering. Requirements elicitation is non-trivial because there is no well-defined technique or process to g*et al*l requirements from the user and customer by just asking them.Different AI techniques are used to optimize the requirement elicitation process. Process optimization is the discipline of adjusting a process so as tooptimize some specified set of parameters without violating some constraint. The most common goals are minimizing cost, maximizing throughput, and/or efficiency. Many software projects are failed to ambiguous or ill-defined requirements. Optimization is a way of achieving optimum of anything. In this paper a literature review is presented on different optimization techniques and a hybrid approach is introduce for optimizing the requirements elicitation process. Bayesian network is an effective uncertain knowledge representation and reasoning method. Fuzzy sets can be used for expressing fuzzy events or fuzzy objectives in some special region. Combining these two theories a hybrid inference system with fuzzy sets and Bayesian networks which are called "Fuzzy Bayesian Networks (FBNs)" is presented.

INTRODUCTION

Requirement elicitation is a process of articulate the requirements of users/buyer/stakeholders of an organization/system. Requirement elicitation is one of the process of requirement engineering.

According toIEEE software requirements are defined as (IEEE, ?**)**

- A condition or capability needed by a user tosolve a problem or achieve an objective.
- Acondition or capability that must be met or possessedby a system or system component to satisfy a contract,
- Standard, specification, or other formally imposeddocument;
- A documentedrepresentation of acondition or capability as in (1) or (2).

Requirements are not limited to the functionalityof the system, as often supposed, but include otheraspects. Differentdefinitions have been presented by different authors. There are both functional and nonfunctional requirements in the system.

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Davis (1993) classifies requirements as:

- Functional requirements
- Nonfunctional requirements
- Performance/reliability
- Interfaces
- Design constraints

Optimization of requirements is the process of getting best possible set of requirements, for this purpose many optimization algorithms are used. Many search based software methods are used to determine the need of users for selecting the requirements and optimize the requirements to get the optimum possible set of requirements. Unambiguous or precise requirements is a most prominent factor that affects the success of a projects. Different optimization algorithms such as meta-heuristic search techniques like genetic algorithms, simulated annealing and Tabu search are used in software engineering problem.

Requirement Elicitation

Requirements elicitation is depicted as the process of discovering therequirements for a system/organization by communicating with customers/system users /stakeholders and others who have interest in the system.

Elicitation Risk and Problems

- **Scope**

Inadequately defined system boundaries and non-essential technical details.

- **Understanding**

hurdles in communication and ill-defined need of stakeholders and domain constraints.

- **Volatility**

lack of commitment of stakeholders for written predefined requirements. Customer/clients,domain experts, buyer, user, software engineer and other stakeholders who are directly or indirectly affected by the project are the sources of requirement.

Requirement Elicitation Techniques and Approches

For many decades different techniques and approaches are used for requirement elicitation. Some of are as follows

- Interview
- Questionnaires
- Task and Domain analysis
- Introspection
- Repertory Grids
- Card sorting
- Laddering
- Brainstorming
- Group work
- Protocol Analysis
- Prototyping

Requirement Elicitation Process

Requirement Elicitation is a sub process of requirement engineering. Requirement elicitation contain following process

- Requirement discovery
- Requirement classification and organization
- Requirement prioritization and negotiation
- Requirement specification

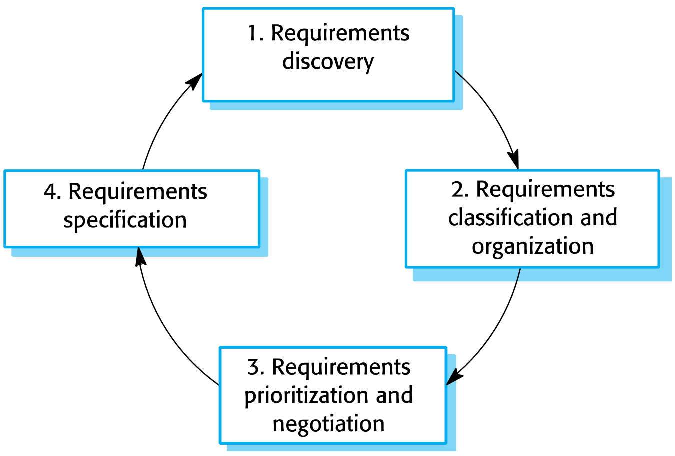

Figure 1. Requirement Elicitation Process

Optimizationtechniques

Artificial Intelligence techniques are used to simulate the human behaviour .different ai optimization techniques are used to improve the process to get the best optimum of a process.This section presents an overview of AI techniques for optimization

Huerstic Techniques (Altaf Badar1 and Umre2, 2014)

Genetic Algorithm (GA) (Mitchell Melanieb, ?: Altaf Badar1 and Umre2, 2014)

Genetic algorithm is an evolutionary search technique based on the Darwin's theory. To get the optimized or optimum solution GA uses genetics and natural selection method**.** Genetic Algorithm is starts with the set of solutions (stated as chromosomes) known as population. Solutions from one population are taken and used to form a new population. It is considered as the new population will be better than the old one. Solutions which are selected to form new solutions are selected on the basis of their fitness - the more suitable they are the more chances they have to reproduce.

GA operator: three types of operator are used in GA

Selection: This operator selects chromosomes in the population for reproduction. The fitter the chromosome, the more times it is likely to be selected to reproduce. (Mitchell Melanieb, ?)
Crossover: This operator randomly chooses a locus and exchanges the subsequence before and after that locusbetween two chromosomes to create two offspring. The crossoveroperator roughly mimics biological recombination between two single−chromosome (haploid) organisms. (Mitchell Melanieb, ?)
Mutation: This operator randomly flips some of the bits in a chromosome.Mutation can occur at each bit position in a string with some probability, usually very small. (Mitchell Melanieb, ?)

Algorithm: (Mitchell Melanieb, ?).

- Start with a randomly generated population of n l−bit chromosomes (candidate solutions to aproblem).
- Calculate the fitness $f(x)$ of each chromosome x in the population.
- Repeat the following steps until n offspring have been created:
  - Select a pair of parent chromosomes from the current population, the probability of selectionbeing an increasing function of fitness. Selection is done "with replacement," meaning thatthe same chromosome can be selected more than once to become a parent.
  - With probability pc (the "crossover probability" or "crossover rate"), cross over the pair at arandomly chosen point (chosen with uniform probability) to form two offspring. If nocrossover takes place, form two offspring that are exact copies of their respective parents.(Note that here the crossover rate is defined to be the probability that two parents will crossover in a single point. There are also "multi−point crossover" versions of the GA in which thecrossover rate for a pair of parents is the number of points at which a crossover takes place.)

- Mutate the two offspring at each locus with probability pm (the mutation probability or

Mutation rate), and place the resulting chromosomes in the new population. If n is odd, one new population member can be discarded at random.

Replace the current population with the new population.
Go to step 2.

lowest temperatures called as freezing point.Bad moves accepted by solutions to break a local entrapment are called as hill climbing (Jiang Chuanwen and Etorre Bompard, 2005; Ingber, 1993; Beck, 1993). The process continues till a specified number of iterations or the freezing point is achieved.

The advantages of SA are its adaptability to implement different optimization problems, simplicity of programming and its ability to overcome local optima entrapment. The major drawback of SA is its reduction in ability to search globally towards the end of the search process.

Table 1. Comparison of Different Heuristic optimization Techniques

Features	Optimization techniques			
	GA	SA	TS	PSO
Development	Prof.john holland 1970-1980	Scott kirkpatrick,c.daniel Gelatt and mario p. Vecchi in 1983 and by vlado cerny in 1985	Fred w.glover in 1986 and formalized in 1989	Dr.eberhart and dr. Kennedy in 1995
Problem area	Combinatorial optimization	Combinatorial optimization	Combinatorial optimization	Continuous and mixed integer optimization
No. Of search point	Multi point	Single point	Single point	Multi point
Application area	Automation, optimizationvehicle routing, quality control, power electronics, clustring etc	Optimization, network confguration, cutomization	Resource planning, telecommunication, vlsanalysis, scheduling, sace planning, energy distribution, moleculer engineering, logistic, pattern classification, flexible manufacturing, waste management, mineral exploration, biomedical analysis, environmental coservation	Optimization, task managementetc.
Run time	Medium	Long	Short	Short

Comparison of Different Heuristic optimization Techniques

Table 2. Comparison table for different Optimization techniques[13]

Prioritization method	Granularity	Complexity	Fault Tolerance Ordinal Scale (1-7)	Scale	Type
Analytical hierarchy process	Fine	Very complex	1	Ratio	Algorithm
Cost-Value prioritization	Medium	Complex	2	Ratio	Algorithm
Cumulative voting	Fine	Complex	3	Ordinal	manual
Top 10 requirements	Extremely Coarse	Extremely easy	--	Ordinal	manual
B-tree prioritization	Fine	Complex	7	Ordinal	Algorithm
Planning Game	Coarse	Easy	6	Ordinal	manual
Theory W	Coarse	Easy	--	Ordinal	Manual

Comparison of Requirement Prioritization Methods

Simulated Anneling

This approach is acquired from the thermodynamic.Annealing is a process of thermodynamics in which low energy state of a solid is obtained and the temperature of the solid is increased till it melts and then the solid is cooled till the particles arrange themselves in a minimum energy state of the solid,the objective function of the problem is similar to the energy state of the solid (Altaf Badar1 and Umre2, 2014).SA is a search algorithm and the search starts with solution with the high or low values of objective function.

The solution moves to other position if the new position has a lower (or higher) value of objective function. If the solution moves to a position with higher (or lower) value of objective function, then such a move is called as bad move. Bad moves are allowed depending on the progress of the search process. Initially more bad moves may be allowed but they are reduced at the end of search process. Bad moves are not accepted at the

Tabu Search

TS was first introduced by Glover in 1986 and was also fully described by Hansen in 1986as a heuristic search techniques for Combinatorial search problem

Algorithm of Tabu Search

- Choose an initial solution *X*
- Find a subset of *N(x)* the neighbors of *X which* are not in the tabu list.
- Find the best one (x') in set *N(x).*
- If F(x') > F(x) then set x=x'.
- Modify the tabu list.
- If a stopping condition is met then stop, else go to the second step.

Particle Swarm Optimization

Particle swarm optimization (PSO) is astochastic optimization technique introduced by Dr. Eberhart and Dr. Kennedy in 1995 taken from the social behaviour of bird flocking or fish schooling and somewhat identical toGenetic Algorithms (GA) a evolutionary computation techniques. It begins with the initialization of population of random solutions and a search for optima by upgrading generations.PSO has no evolution operators like GA(crossover and mutation). In PSO, the potential solutions are called particles. Each particle keeps track of its coordinates in the problem space which are associated with the best solution (fitness) it has achieved so far. (The fitness value is also stored.) This value is called *pbest*. Another "best" value that is tracked by the particle swarm optimizer is the best value, obtained so far by any particle in the neighbours of the particle.

This location is called *lbest*. When a particle takes all the population as its topological neighbours, the best value is a global best and is called *gbest*.PSO gets better results in a faster, cheaper way compared with other methods. Another reason that PSO is attractive is that there are few parameters to adjust and Particle swarm optimization has been used for approaches that can be used across a wide range of applications, as well as for specific applications focused on a specific requirement (Altaf Badar1 and Umre2, 2014).

Hybrid Techniques of Ai

Hybrid techniques are integration of two approaches incorporated to intensify the performance of optimization techniques. Some of the hybrid techniques are given below: Simulated annealing is integrated with adaptive genetic algorithm to solve active power loss minimization in (Keyan *et al*., 2006). Genetic algorithm is deployed for the global search whereas simulated annealing is deployed for local search. SA is employed after a new generation is generated in each iteration.

Three optimization techniques: Genetic Algorithm, Simulated Annealing and Tabu Search are merged in (Yutian Liua *et al* 2002). Simulated annealing is used to improve the convergence of genetic algorithm whereas Tabu search is applied to further improve the obtained results. A combination of genetic algorithm and simulated annealing is improved to handle continuous variables with the help of Primal Dual Interior Point method in (Guo Liya *et al*., 2010).

In (Jingui *et al*., 2010), the optimization techniques of GA and PSO are combined. Genetic algorithm is used to obtain good particles for the initial population of PSO. Also the values of constants c1 and c2 in PSO are varied for better search capabilities. PSO is improved with the addition of chaos mapping and linear interior point in (Jiang Chuanwen and Etorre Bompard, 2005).

Comparison of Different Heuristicoptimization Techniques

Different AI techniques have its own advantages and disadvantages.

Value Based Optimizzation Techniques

AHP (Analytical Hierarchical Process) (Gurkiran Kaur and Seema Bawa, 2013, Muhammad Ramzan *et al*., 2011)

AHP was developed by Thomas saaty, is a multi-criteria decision making techniques to prioritize the user requirements. In AHP requirements are compared to each other pair wise and prioritize. Risk, time, advantage and disadvantage are different aspects are parameterized to assess the requirement, n (n-1)/2 comparison are needed in AHP where n is the number of requirements. Consistency check and fault-tolerance are two advantage of AHP.

- AHP uses 5 steps to assess the requirements-
- Establish completeness of requirements.
- Apply the pair-wise comparison method to assess the relative value.
- Apply the pair-wise comparison method to assess the relative cost.
- Calculate each candidate requirement's relative value and implementations cost and plot each on a cost-value diagram.
- Use the cost-value diagram as a map for analyzing the candidate requirement

Cost-Value Approach (Gurkiran Kaur and Seema Bawa, 2013, Muhammad Ramzan *et al*., 2011)

Cost-value approach is one of the method to prioritize the requirements. This method is based on the relationship of value to cost of implementation. In this technique value and cost are used as parameter. Cost–value approach uses five steps to prioritize the requirements.

- A careful review of requirements to determine their completeness clarity and non-ambiguity.
- Application of AHP's pairwise comparison method to determine the relative valueof the all requirements.
- An estimate of relative cost for implementation of requirements by experiencedsoftware engineers using AHP's pairwise comparison again.
- Calculation of relative value and implementation cost of each candidaterequirements and plotting these on a cost–value diagram with value on the y axisand estimated cost on the x axis.
- An analysis is performed using this plot to determine feasibility of eachrequirement to be incorporated in the system. The analysis involves throughdiscussions and brainstorming.

B-Tree Prioritization

B-tree (BT) technique introduced by Md.Rizwan Beg, is a systematic method in which the number of comparison required must be low. This is a method to prioritize anyrequirement without influencing already defined prioritization. B-treetechnique can prioritize the requirements at run time. At the same time, the number of comparisonsrequired is limited as well since only new requirements need to be prioritized whilealready prioritized requirements are not affected. (Gurkiran Kaur and Seema Bawa, 2013, Muhammad Ramzan *et al*., 2011)

Cumulative Voting

This method is also known as 100-dollar test proposed by Leffingwell and Widrig. Main purpose of this technique is to present analysis during discussions.Each stakeholder is assigned representative money of $100 which he can use to invest inrequirements.

Each stakeholder can assign any number of dollars to any requirements. Atthe completion of assignment, totaling of dollars assigned to every requirement isperformed and based on this total, requirements are prioritized (Gurkiran Kaur and Seema Bawa, 2013, Muhammad Ramzan *et al*., 2011). Easy applicability and understandability are two major advantages of this method.However, when we deal with hundreds or even thousands of requirements, this techniquefails to meet its objective of effective prioritization. Some other drawbacks of thistechnique involve heavy human intervention as well as degree of experience required toundertake such a serious activity (Gurkiran Kaur and Seema Bawa, 2013, Muhammad Ramzan *et al*., 2011).

Top-Ten Requirements

In this technique users select their top ten requirements from the whole set of requirements. This scheme is not strictly a prioritization scheme as it can be used to only extract agroup of most critical requirements. This is an easy to use technique with low sophistication but with verybad granularity (Gurkiran Kaur and Seema Bawa, 2013, Muhammad Ramzan *et al*., 2011).

Planning Game (Gurkiran Kaur and Seema Bawa, 2013, Muhammad Ramzan *et al*., 2011)

In Planning Game (PG) requirements are written by the customer on a card. Then the customer divides the cards that are the requirements into three different piles. As Beck presented, the piles should have the names; "those without which the system will not function", "those that are less essential but provide significant business value" and "those that would be nice to have" (Beck, 2001).Programmer is also involved who takes into account the time each requirement would take to implement and then he sorts the requirements into three different piles i.e. sort by risk, with the names; "those that can be estimated precisely", "those that can be estimated reasonably well" and "those that cannot be estimated at all". (Muhammad Aasem *et al*., 2010)

Theory W (Gurkiran Kaur and Seema Bawa, 2013)

Theory-W was proposed by (Boehm, Park) at the University of Southern California .It is also known as "Win-Win." An important point is that it supports negotiation to solve disagreements about requirements, so that each stakeholder has a "win." It has two principles:

- Plan the flight and fly the plan.
- Identify and manage your risks.

The first principle seeks to build well-structured plans that meet predefined standards for easy development, classification, and query. "Fly the plan" ensures that the progress follows the original plan. The second principle, "Identify and manage your risks," involves risk assessment and risk handling. It is used to guard the stakeholders' "win-win" conditions from infringement. In win-win negotiations, each user should rank the requirements privately before negotiations start. In the individual ranking process, the user considers whether there are requirements that he or she is willing to give up on, so that individual winning and losing conditions are fully understood.

Theory-W has four steps:

- Separate the people from the problem.
- Focus on interests, not positions.
- Invest options for mutual gain.
- Insist on using objective criteria.

Comparison of Requirement Prioritization Methods

In Table complexity, Fine to Coarse in terms of Granularity, Ratio and ordinal in terms of scale.

Integrated Approach for Optimization

In this paper a theoretical approach for optimizing the requirements is introduced by the integration of Fuzzy and Bayesian network.

Fuzzy Logic

Fuzzy logic incorporate a method to formalize reasoning when dealing with vague terms.Fuzzy logic accumulate membership functions, or degrees of truthfulness and falsehoods. Or aswith Boolean logic, all the numbers that fall in between 0 and 1.

General Forms

Unconditional and unqualified Proposition: *Q* is *P*

Example: Temperature (*Q*) is high (*P*)

$$\Rightarrow \mu_Q(x) = \alpha \text{ then } result x = \mu_P^{-1}(\alpha).$$

Unconditional and qualified Proposition: proposition (*Q* is *P*) is *R*

Example: That Coimbra and Catania are beautiful is very true.

$$\min\{\mu_{co}(x), \mu_{ca}(x)\} = \alpha, \text{ then } result x = \mu_{vtrue}^{-1}(\alpha)$$

Bayesian Network

Bayesian Network is also known as probabilistic directed acyclic graphical model type of statistical model that represents a set of variables that must be random and their dependencies on the basis of condition represented through a directed acyclic graph (DAG).In a BN theonly constraint on the arcs allowed is that there must not be any directed cycles: Returning to a node from other node simply by following directed arcs is impossible. Such networksare called directed acyclic graphs, or simply dags.There are certain steps that a knowledge engineer must stipulate whenbuilding a Bayesian network.

Fuzzy is used to prioritize the requirements and quantify the attributes. Bayesian classifier is used to classify the data. Hybrid of fuzzy and Bayesian is used to optimize the elicitation process. In this paper we optimize process by prioritize and classify the requirements.

Conclusion and Future Scope

In this paper, different optimization techniques are pointed out systematically. Each and Every technique has its own pros and cons but more research is needed.

To optimize the requirement elicitation process an integrated approach is more potent to use than the others. In this paper a mixed approach for optimization using Fuzzy logic and Bayesian network is pointed theoretically. In reference to the requirement elicitation process requirement are prioritize using fuzzy and classified through bayesian. Future work is to widen this Theory by developing an algorithms for Optimization. Different other techniques such as Genetic algorithm, Particle Swarm Optimization, Ant Colony Optimization, Tabu Search, Simulated Annealing are presented in this paper.

Improved or hybrid artificial intelligence methods have been developed to combine the better performance characteristics of various search methods.

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