Decision making framework for optimizing construction management objectives: A review.

SAMI MUSTAFA MOHAMED ELHASSAN[*1], NOOR AMILA WAN ABDULLAH ZAWAWI[2] & ZULKIPLI B. GHAZALI[3]
Civil Engineering Department[1&2]
Management & Humanities Department[3]
Universiti Teknologi Petronas
Bandar Seri Iskandar – 31750 Tronoh – Perak Darul Ridzuan
MALAYSIA
sami.utp@hotmail.com

ABSTRACT: Construction project including group of interrelated work activities constrained that by 13 knowledge areas. It is made up to achieve specific objectives. During management processes objective functions and constraints have to be optimized. This paper discusses the difficulties appear during making decisions in construction management. Then it addresses how optimization techniques can provide tools for making optimal or best decisions with respect to construction project management. It reviews s some literature concerned with using artificial intelligence algorithms in optimization models applied to make decisions required for managing construction project. This paper aims at presenting the general steps required in this area of research and shows that there are still many research gaps in making decision in construction projects and lot of opportunities for future studies.

Key-Words: - Optimization, Genetic Algorithm, Construction Management Constraints, cost, Time, Safety.

1 Introduction

Project is a temporary endeavor undertaken to create a unique product, service or result. For this creation, applications of knowledge, skills and tools are required. Project management includes five process groups; Initiating, Planning, Executing, Monitoring and Controlling, and Closing [1].

Different project types, including construction ones, are made up of a group of interrelated work activities constrained by a specific scope, budget, and schedule to deliver capital assets needed to achieve its objectives [2]. These constraints, sometimes called knowledge areas, include integration, scope, time, cost, quality, human resource, communication, risks and procurement [1]. For construction projects there are four unique constraints; Safety, environment impacts, finance and claims [3]. To improve the efficiency and effectiveness of managing construction projects all these 13 constraints, 9+4, should be considered.

Construction project can be defined as a 13D model in which 5 process groups are applied to create a unique product or service. For this huge number of dimensions, construction considered as one of the most complicated and fragmented industries. Over the last five decades, cost, time and quality - known as Iron triangle- are used for measuring the success of the project management [4]. But recently the success of implementing management process in construction project is measured by the success of the project management on staff organizing and preparing plans of executing and controlling time, cost, material, quality and environmental constraints [5].

2 Decision Making Optimization

A decision is the agreement to adopt an alternative(s) to resolve that issue. The processes of making decisions facing two difficult situations: ***-Dynamic situations*** Where decisions may be affected later if additional alternatives are generated, or if criteria and preferences are changed [6]. ***-Complicated situations*** Where decisions are made under influence of multi-objectives [7]. For this situation objectives are generally conflicting and

preventing simultaneous optimization of each objective [8].

Optimization methods are used to solve these problems; when there are some objective functions to be optimized in addition to constraints of decision variables [9]. Optimization models aim at finding optimal or best solutions with respect to some predefined performance objectives.

Artificial intelligence algorithms solve multi-objectives optimization problems by emulating the human brain [10]. The most popular Artificial Intelligence paradigms include Genetic Algorithms (GAs), Fuzzy Logic (FL), Artificial Neural Network (ANNs) and Ant Colony Optimization (ACO).

3 Using optimization in developing decision making frameworks for Managing Construction Projects:

Construction projects are managed in thirteen dimensions model by applying five management processes. But most of researches focusing on time and cost dimension and few ones considered quality and environmental impacts. For construction industry in Malaysia, safety constraint may need more consideration because the governmental reports showed that construction is at the top of industries having accidents which cause death in Malaysia [11].

The phases that most of researchers considered are design and planning phase. Only few of them studied controlling phase. Kandil consider construction/execution phase; using Genetic Algorithm to make optimum planning decision for allocating resources considering time, cost and quality constraints [12].

Previous application of Artificial Intelligence Algorithms (AIA) in construction decision making process can be classified into three categories; ***-Decision related to evaluation design and planning alternatives***; Genetic Algorithm [13], Linear and non-linear algorithms [14] and Simulated Annealing algorithm and fuzzy logic algorithm [15]. ***-Decisions concern with allocating resources during construction phase***; Genetic Algorithm [16] and [17], Ant Colony Optimization [18]. ***-Some decisions may be affected by both of the previous problems***; evaluating options and allocating resources. Like coordinating tasks; Enumerative Branch-And-Cut algorithm (EBAC) [19].

Most of these studies concluded that availability of data is the most critical problem [20] and [21]. Any algorithm needs specific type and amount of data; availability of data is an important factor for selecting algorithm.

Evolutionary Algorithms (EA) are those ones which are applied when given a population of individuals then natural selection is done due to the environmental pressure and this selection causes a rise in the fitness of the population. This type of algorithms involved most algorithms used for optimizing decision in construction management; like Genetic Algorithm, Particle Swarm and Ant Colony Optimization.

The following section discusses some advantages and disadvantages of some evolutionary algorithms: -The main characteristic of ***Genetic Algorithms*** (GA) is that they work on multi points environment, this gives them many advantages; they do not take long time to evaluate huge number of solutions, bad and missed data do not affect final results because they will be discarded. Other important advantage is that they do not require knowing the relation between problem variables. But its disadvantage is that discarding of bad or missed data may lead to suboptimal solutions [22]. -
-***Ant Colony Optimization*** (ACO) algorithms are like (GA); do not take long time to find acceptable solutions. But they depend on experimental bases rather on theoretical ones [23]. -
-Advantages of the basic ***Particle Swarm Optimization*** algorithm (PSO) [24]; It can be applied into both scientific research and engineering use.PSO has no overlapping and mutation calculation. So the speed of the researching is very fast. The calculation in PSO is very simple. PSO adopts the real number code, and it is decided directly by the solution. The disadvantages include, the method easily suffers from the partial optimism, and the method cannot work out the problems of scattering, optimization and non-coordinate system.

After selecting the suitable algorithm according to its capabilities, advantages and disadvantages, required data have to be collected through questionnaires, interviews, and case studies. To computerize the previous processes, some suitable software is required like V.B.6, Ms Excel and or Matlab. Then the multi-objectives problems will be coded to be analyzed and solved by using the selected algorithm.

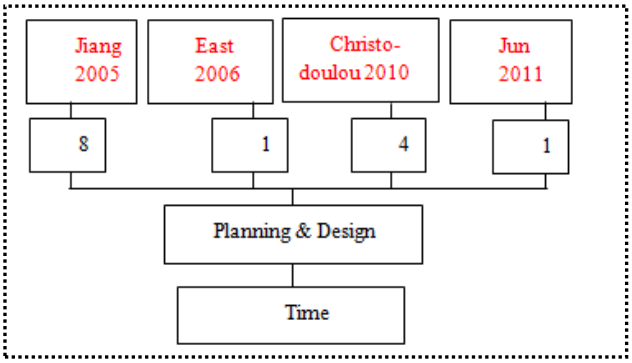
ISBN: 978-1-61804-137-1

4 Discussion

Making decisions during construction projects management require multi objective optimization tool, and Artificial Intelligence (AI) provides many tools for this purpose.

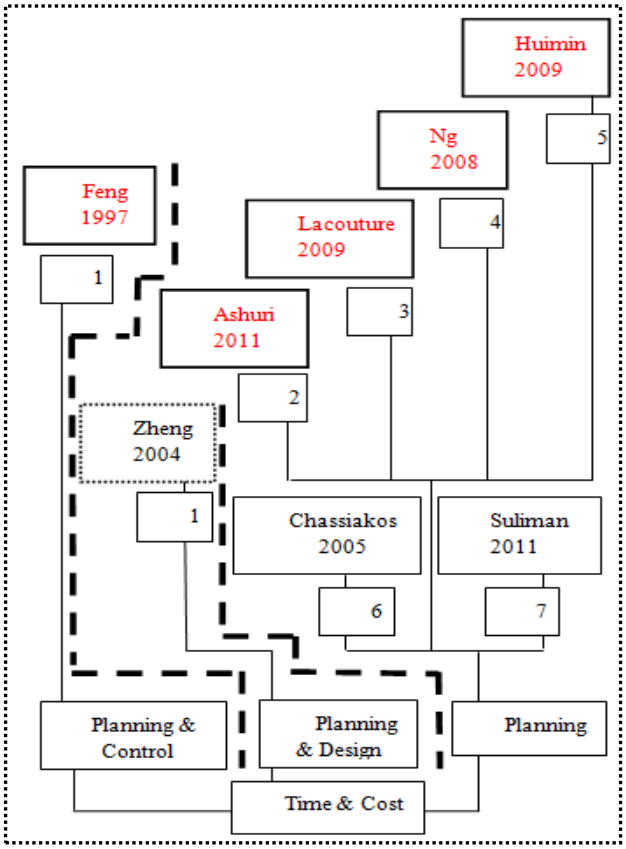
Most of Artificial Intelligence applications used in supporting decision making in construction management are focusing on resources allocation, evaluation design alternatives and optimizing decisions under mutual cost and time constraints. Most of previous studies were focusing only on cost-time tradeoff problems. There is a need to extend these studies to include other criteria like quality and environmental impacts and safety. Few studies addressed issue of multi-objective by adding third criteria to time and cost like environmental performance [20], quality [12 and environmental impacts [21. But they addressed it only through design and/or planning phases, hence there is need to extend the scope of such studies to cover other management processes; executing and controlling. The main problem for most of these researches is availability of data. As new optimization tools and techniques developed there will be capability to include more objectives and constraints; applying artificial intelligence algorithms in construction management optimization model will be a promising area for a lot of researches.

The following three figures represent summary of literature review related to using artificial intelligence algorithms to develop optimization models for different combinations of construction projects objectives. *Where: [1]Genetic Algorithm (G.A.), [2] Enumerative Branch-And-Cut (EBAC), [3] Fuzzy Logic (FL), [4]Ant Colony Optimization (ACO), [5] Artificial Neural Network (ANN), [6]Memetic Algorithm (MA) [7]Particle Swarm Optimization (PSO) [8]Simulated Annealing Algorithm (SAA).*



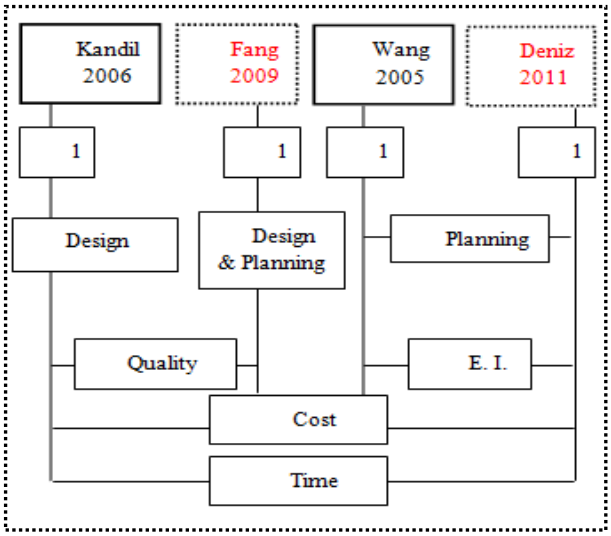
Fig(1): Time problem

Figure 1presents that there are four studies based on allocating resources in design and planning phases to make decisions concerns with scheduling, each of these studies use different AIA.)



Fig(2): Time and cost tradeoff problem

Figure 2addresses studies those combined many construction project constraints in different phases. although all of them use the same algorithm but some of them based on allocating resources and the other on arranging design and planning options.)



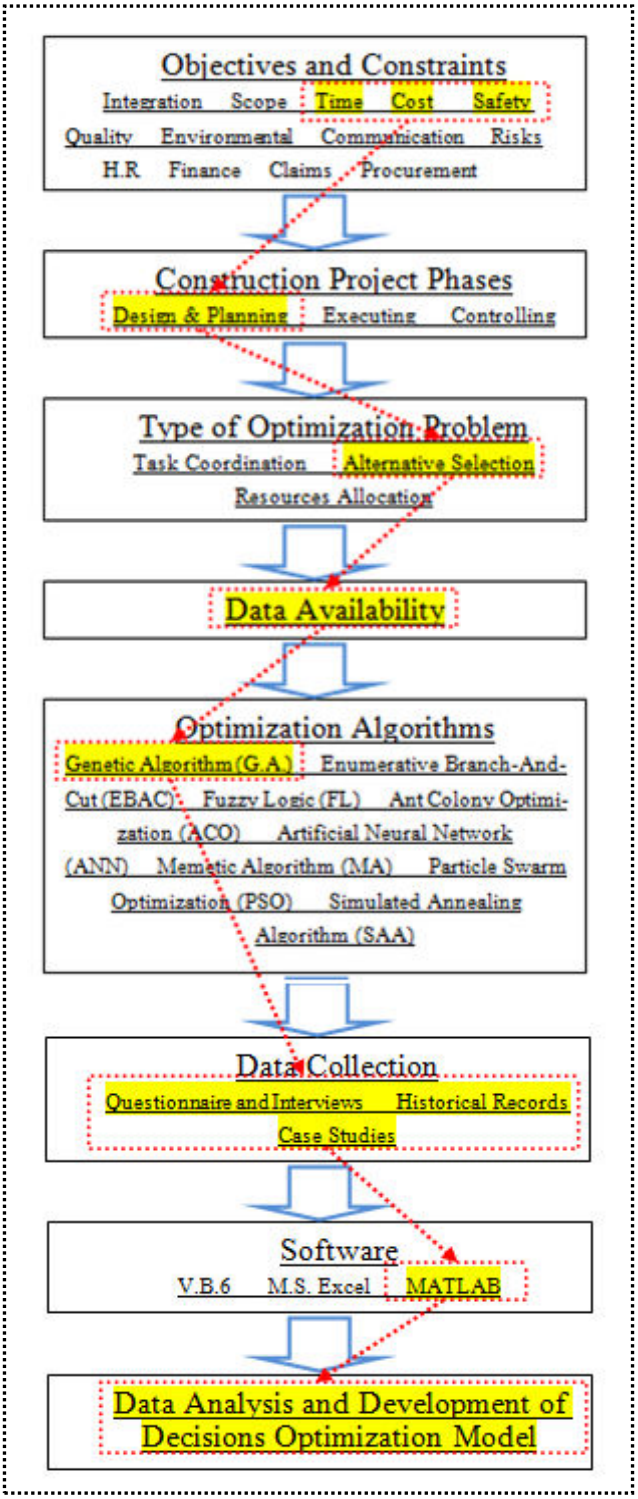
Fig(3): Some combinations of quality, cost, time and environmental impacts

ISBN: 978-1-61804-137-1

Figure 3shows that there are six research papers about using six different Artificial Intelligence Algorithms (AIA) in planning phase to make decisions which solve the problem of time and cost tradeoff. Also there is studies suggest applying GA to solve the same tradeoff problem; one of them considers design and planning phases and the other focus on planning and control phases. The study in the dotted box based on the concept of arranging design and plan options, while the other studies based on allocating resources.)

5 Conclusion

After reviewing these sixteen research papers the following figures can summarize the application artificial intelligence algorithms in decision making framework. The common recommendation from all these sixteen studies is that they are promoting using (AIA) in making decision for managing construction project. And the main problem noted by all of them is concerned with availability of data.
Figure (4) shows the general flowchart of applying AIA to develop decision making framework to optimize different objectives of construction projects. According to this figure many future studies are expected because there are many combinations of constraints can be considered and as new AIA is developed the opportunities to achieve better decision making framework is increased. The dotted, highlighted selection and arrows show in figure (4) is an example for one of these future studies.



Fig(4): Flow chart for using optimization algorithms for developing decision making framework in construction management.

6 References

[1] PMI (2004). "A guide to the Project Management Body of Knowledge", project Management Institute, USA.

[2] Fleming, G. (2009). "construction project management handboosk". Report No. FTA-CA-26-7077-2009-1 U.S. department of transportation, USA.

[3] PMI, (2000). "Construction Extension to A Guide To the Project Management Body of Knowledge", Project Management Institute, USA.

[4] Atkinson, R. (1999). "Project management: cost, time and quality, ywo best guesses and phenomenon, its time to accept other success criteria". International Journal of Project Management. 17(6), 337-342.

[5] Nwachukwu,C.C.; Ibeawuchu, E.; and Okoli,M.N.(2010). "Project management factor indexed; a constraint to project implementation success in construction sector of developing economy". European Journal of scientific research, 43(3), 392-405.

[6] Ullman, D.G. "The ideal engineering decision support system". http://www.robustdecisions.com /theidealenginsyste1.pdf.

[7] Ruotsalainen, H. (2010). "Interactive multi-objective optimization in model based decision making with application". Ph.D. thesis, University of Kuopio-Finland.

[8] Yulan, J., Zuhua, J. and Wenrui, H. (2008). "Multi-objective integrated Optimization research on preventing maintenance planning and production schedule for a single machine".International Journal of advanced manufacturing technology, 39(9-10).

[9] Murty, K.G. (2003). "Optimization models for decision making". University of Michigan, Ann Arbor-USA.

[10] Ko, C. H. and Cheng, M. Y. (2007). "Dynamic prediction of project success using Artificial Intelligence". J. Constr. Eng. Manage., 133(4), 316-321.

[11] DOSH a; Department of Occupational Safety and Health, (2012). " Report of Occupational accidents by sector for the category of death until march 2012".

[12] Kandil, A., and El-Rayes, K. (2006). "MACROS: Multi-objective Automated Construction Resource Optimization System". J. Manage. Eng. 22(3), 126-134.

[13] Zheng, D. X. M., Ng, S. T. and Kumaraswamy, M. M. (2004). "Applying a Genetic Algorithm-based multi-objective Approach for time-cost optimization". J. Constr. Eng. Manage. 130(2), 168-176.

[14] Chassiakos, A. P. and Sakellaropoulos, S. P. (2005). "Time-Cost Optimization of Construction Projects with Generalized Activity Constraints". J. Constr. Eng. manage., 131(10), 1115-1124.

[15] Suliman, M.O.; Kumar, V. S. S.; and Abdulal, W.(2011). "Optimization of uncertain construction time-cost trade off problem using Simulated Annealing Algorithm" Information and Communication Technologies (WICT), 2011 World Congress-India.

[16] East, E. W., and Liu, L. (2006). "Multi-project planning and resource controls for facility management". J. Constr. Eng. Manage. 132(12), 1294-1305.

[17] Jun, D. H. and El-Rayes, K., (2011). "Multi-objective optimization of resource leveling and allocation during construction scheduling". J. Constr. Eng. Manage. 137(12), 1080-1088.

[18] Christodoulou, S. (2010). "Scheduling resource-constrained project with Ant Colony Optimization Artificial Agent". J. Comput. Civ. Eng. 24(1), 45-55.

[19] Jiang, G. and Shi, J. (2005) "Exact Algorithm for solving project scheduling problems under multiple resource constraints". J. Constr. Eng. Manage., 131(9), 986-992.

[20] Wang, W. (2005). "A simulation-based optimization system for green building design". Ph.D. thesis, Concordia University – Canada.

[21] Deniz, G. O., Zhu, Y., and Ceron, V. (2011). "Time, Cost and Environmental Impacts Analysis on Construction Operation Optimization Using Genetic Algorithms." J. of Manage. in Eng. Doi:10.1061/(ASCE)ME.1943-5479.0000098.

[22] Jakobsent, T. (2006) "Genetic Algorithm Abstract". www.subsimple.com/genealgo.

[23] Shekhawat, A.; Poddar, P. and Boswal, D. (2009). "Ant Colony Optimization algorithms : introduction and beyond". Artificial Intelligence seminar, Indian Institute of Technology, Bombay – India.

[24] Bai, Q. (2010). "Analysis of Particle Swarm Optimization algorithm" J. computer and information science, 3(1), 180-184.