

Goal Programming Approach: A Glorious Past and Promising Future Applications.

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Abstract : In the last 50 years or more there has been a tremendous development in multi-criterion decision making and in multi-objective programming (MOP). Goal Programming (GP) is the mostly commonly known model of MOP and is considered as the 'workhorse' of MOP. It is today more applicable, supported by a network of researchers and continuously feeding it with theoretical as well as application developments in all of these with great Successes. This paper gives us a picture which summarizing the history of GP and suggests a vast area of research in this era of Globalization.

Keywords: Goal programming, Multi-criteria decision making, Multi-objective programming

1. Introduction

The basic idea of GP has been traced by Romero (1992) to study by Charnes and Cooper (1955) on executive compensation. While the term goal programming did not appear in this 1955 article, but according to Romero (1992), it was not until Charnes and Cooper's 1961 linear programming text book, Management models and industrial applications of Linear programming that the term goal programming appeared. Interestingly, it was not present a unique or revolutionary methodology, but an extension of linear programming (LP). In the Charnes and Cooper book, goal programming was suggested for use in solving unsolved LP problems. Indeed GP was not even cited as the term in the index of the Charnes and Coopers book (1961).

From this beginning as an extension of LP, Goal Programming has distinguished itself in the years since as a unique problem solving methodology. Given the popularity of Goal Programming and the large number of active researcher's, international conferences were organized to allow them the opportunity to present their findings. Thousands of paper presentations have been given to the subject of Goal Programming at annual meetings of professional societies, particularly the operation research society of America, the institute of management science, the institute of decision sciences and the international society of multiple criteria decision making. Numerous text books and monographs have been devoted in part or totally to the subject of Goal Programming.

The series of international conferences was held on the topic of multi-objective programming and goal programming (MOP/GP) were initiated in 1994 and were solely devoted to provide a forum in which researchers and practitioners could meet and learn about recent development in GP. The participants at these conference's whose common interest is multi-objective analysis are from various disciplines such as optimization, multi criteria decision aid, mathematical programming, mathematical modelling and computational applications. Three conference's which was held back to back in the year 1994, 1996 and 1998. In June 1994 first conference which was held at united kingdom, the collection of interesting papers presented at this first GP conference with organizing committee of M. Tazim, R. Hashim, D. Jones, S. Mardle and K Marrazavi. . The second conference chaired by R Caballero, was organized by university of Malaga, in Spain. The paper presentation at this conference can be found in Caballero at el (1997). The third important conference was held at university of Laval in Quebec city Canada in May-June 1998 and was organised by J-M Martel and B-Aouni with OKettani. A wide range of topics covered during this conference such as data envelopment analysis, Application of MOP/GP, Fuzzy Sets and artificial intelligence and interactive MOP/GP.

2. Historical Sketch

As we mentioned above the concept of Goal Programming was conceived by Abraham Charnes and Willam Cooper nearly half century ago. The tool was extended and enhanced by their students and researchers most notably by Ijiri, Ignizio, Lee, Clayton and Jones. In its original form, GP have been developed to deal with multiple objectives decision making problems. Ignizio in 1960 extended the method to both non-linear and integer models, develop different algorithms and successfully applied them to a number of important real life problems. Ijiri (1965) introduce a concept of goal ranking where a priority factor is assigned to each goal. In this way, the most important goal will be satisfied before the goal of low priority. Lee (1972) have discussed modified simplex method to solve GP problems. In the same year Lee prepared a FORTRAN program for goal programming which depends on the idea of modified simplex method.

Ignizio (1976) also developed the same programmed for solving the linear programming as well as non-linear goal programming. In 1982 he introduced the idea of non-dominated solution in the lexicographic model of GP. He called this goal programming formulas as Augmented GP. This formula results in a compromise solution. Ignizio not stopped here, he along with his Crowder and Spositioin 1991 developed the suited computer codes, which helps in solving sequential linear GP problems in very efficient manner. Steuer in 1990 prepared an ADBASE operating manual which solves multiple objective programme for all efficient extreme points and all unbounded efficient edges.

The historical back ground of GP was very vast and expanded in rapid rate with short period of time because the growing complexity and technological development in recent years. Many real life problems needs systematic approach like the rapid expansion of higher education both in size and quality requires systematic approaches and dynamic planning for efficient resource allocation. Many researchers have studied in this field important among them are Lee, Clayton and Lawrence et all. Some of the applications are as fallows; management of the reservoir watershed, management of solid wastes, marketing and quality control (Sengupta, 1981), transportation problems, subject to budget restraint (Chalam, 1994), Telecommunication (Sueyoshi, 1990), Agriculture and Forestry (Remero, 1991), Industrial application as well as Aviation (Suzuki and Yashizawa, 1994). In recent years many articles and research papers published in different Journals of the world [Salah R. Agha, 2005] published an article, use of goal programming and integer programming for water quality management a case study of Gaza strip in European Journal of Operation Research. The problem of optimal allocation in stratified sampling designs discussed by several authors (see, for example, Gosh (1958), Yates (1960), Hartley (1965), Folks and Antle (1965), Gren (1966), Kokan and Khan (1967), Chatterjee (1972), Bethel (1989), kreienbrock (1993), Khan *et al.* (1997). Ahsan *et al.* (2005), Kozak (2006), Lone *et al.* (2015, 17, 17), Ansari *et al.* (2009), etc).

Regarding the development in methods the goal programming models noted many extensions like weighted GP, lexicographical GP, Integer GP, fractional GP, non-linear GP, stochastic GP, fuzzy GP, and GP with intervals and MINMAX GP. According to Dinklebach (1973) and Steuer 1979), non-linear GP used to generate a set of non dominated solutions. Stochastic approach to GP has been investigated by Contini (1968), Dyer (1972) and Spronk (1978) have proposed interactive Goal Programming.

Another interesting development for GP is to utilization as a statistical tool for estimation. Research suggested that GP could be alternate method for conventional statistics. It gives flexibility for modeling the estimation process and provides the platform for researcher's which helps the knowledge and experience can be input to the parameters estimation. Lee and Morris (1977) works in the field of integer goal programming gains the popularity by using discrete variables in the application part. The process not stopped here different research articles and papers published in recent years on integer goal programming such as "Use of goal programming and integer programming for water quality management and construction of time schedule using integer goal programming.

Despite few criticisms in early 1990's, especially in the case of the aggregations procedure of deviations related to objectives having incommensurable units of management. But today's goal programming model, methods and algorithms are different significantly from those employed even in the early 1990's. Goal programming as discussed may be combined with various tools from the artificial intelligence sector. So as to provide an exceptionally robust and powerful means to model, solve and analyze a host of real world problems. In other words today's goal programming while maintaining its role as the "work horse" of multiple objective decision analysis is much different tool than that described in most text books, even those published relatively recently. Thus one can say GP has a glorious history and promising future.

3. Future trends in Goal Programming

Goal programming research has had a great past and will have a great future in helping to improve decision making. Making decisions is undoubtedly one of the most fundamental activities of human beings. Many real world complex decision system involving the optimization of several conflicting objectives. Multi-criteria decisions problem is a generalization of the traditional classical single objective optimization. There are many reasons for increasing interest in GP problems to the present society. Firstly, most of the decision problems are inherently multi-objective in nature and hence decision making using classical methods does not reflect the underlying reality. Secondly in many decision problems in which ranking of potential alternatives is required. Thirdly many problems that occur in classical single objective models can better be viewed as multi-objective in nature. The reason for the multiple objective natures of these problems is that the outcomes associated with decision are multi-dimensional. Thus the trends in the types of GP research that appear in the literature are important to observe in order to take part in making contribution to that future.

The purpose of this paper is to summarize and conclude presentation on GP. This is accomplished with commentary and suggestions on trends in GP research. This paper will present a commentary on how GP is currently positioned for the growth in research.

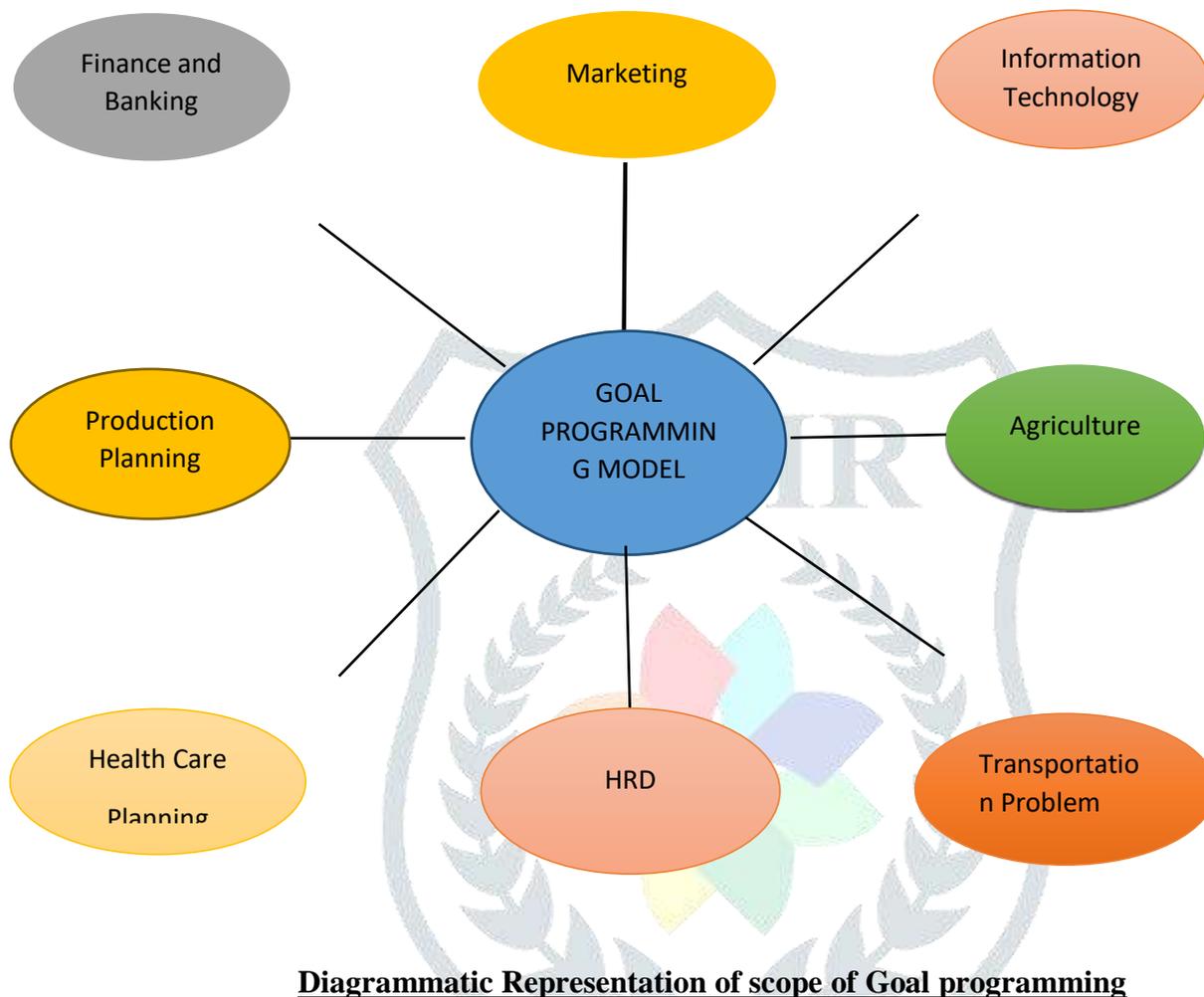
There are many optimistic trends that can be observed by the researchers about GP. Multi-criteria decision making (MCDM) is one of the positive trend that the GP is viewed as a subject within the field. MCDM increases dominance in the field of operation research (OR) which helps to bring the students and newly researchers interested and research opportunities for GP. This survey was done by operation research society America and the institute of management science, both the professional researchers and recently graduated students were pulled in the survey. In the resulting ranking, MCDM was ranked 5th by the professional and 7th by the recent graduates. The other category that GP might have fallen into mathematical programming, in which case the professional ranked this category 6th and recent graduates ranked 5th. In either case, this was the first time MCDM had made it into the top ten ranking and a growing sign of GPs relative importance as a decision making methodology.

Another trend that is observed about GP for growth in recent years is the increased number of conferences and seminars devoted to the subject. The international conference on MCDM which is sponsored by the international society on multiple criteria decision making held its 12th annual meet at Hague Germany in 1995. Although it is clear that many of the fundamental questions regarding goal programming have been answered in recent years which will create many avenues for future research in theoretical or mathematical development and continual stream of new application areas arises which can benefit from goal programming analysis. From last 15 years some of these journals have included computer and operation research, INFOR, Agricultural system and journal of advanced transportation. Apart from few exceptions GP as a subject have numerous applications particularly in the area of applied science, agricultural, engineering, management, philosophy, finance and accounting. The number of innovations and suggestions can be summarized but it may be known to researchers and are not articulated or practiced by them. These ideas are particularly meant to challenge and simulate idea creation for newly researchers. Indeed some of these innovations and suggestions in GP may help students and researchers come up with an idea for the thesis and for application purpose, so that they can take part in making contribution to the future. It is hoped that future work in goal programming will be conducted with a growing awareness of such linkages and a new generation of hybrid algorithms and formulations

can be developed with symbiotic advantages for goal programming. Some of the innovations and suggestions may be as follows:

- I. GP should be taught in school as the subject of interest and research which helps to present basic ideas or strategies for teaching GP to the students. Recent research on GP enhancing the students to understand newer inter active GP methodologies and the use of computer graphic system. While the potential impact of the newer methods has not yield a chance to show up in the literature, but helps to increase the interest in GP in a new generation students. It is clear that a major growth area worldwide has arisen with the communications revolution and the advent of the World Wide Web. The issues involved give rise to many issues relating to the field of Operational Research. It is inevitable that many of these models are going to involve multiple objectives and that a subset of these will be suitable for analysis and solution using goal programming methodology. The goal programming community should therefore look forward to the growth of the 'Computing and IT' application field as goal programming methods are applied to these new technologies. It is also likely that goal programming will continue to have a continuing presence as a strategic management tool to answer questions posed by the changes. New businesses and old businesses looking for new strategies in the rapidly changing markets present good opportunity for goal programming to be used, especially in conjunction with other decision analysis tools and techniques.
- II. New technologies can lead to new applications particularly in the area of applied science, agriculture, engineering and management. New technologies are constantly being invented and introduced in these fields. Each introduction represents a possible idea of application. One additional point of opportunity that can be mentioned is the fact that automated system that reduce variability in the application environment gives a robot replacing a human on an assembly line it improves the use of deterministic methods. Methodologies like GP, as variability in production processing is removed more deterministic modeling methodologies can be applied because of manufacturing constructing of the automation. Agriculture is the backbone of economy due to changing weather conditions, water problem, labor problem and the economic conditions, agriculture sector faces many constrains. To achieve refused for production we must think about GP models for agriculture sectors. The GP model for multi objective programming is an important tool for studying various aspects of agriculture sector, Human resource development, information technology and transportation.
- III. Innovations in finance and banking crisis management can lead to new GP modelling opportunities. Financial planning is one of the key area of multi-objective analysis. This involves problem on capital budgeting, working capital management and portfolio selection. Both capital budgeting and working capital involves long range decision and short term investment respectively. The long range decision regarding the allocation of capital investment among multiple projects. The short term investment and financing decisions involves multiple objectives related to its profitably, liquidity and use of financial leverage. The purpose of the multi objective programming is to resolve such conflicting situations. GP is one of the method to solve the problems involving multi-objective decision making problems. Theeconomic crisis situation and complex environmental and societal processes over the past years indicate the need for new mathematical model constructions using GP to predict their effects. GP model is a powerful and robust technique for solving hierarchical decision making problem. It has been applied in many real life problems such as agriculture, biofuel production, economic system, finance, engineering, banking management science, transportation. Bank crisis management is one of the main problem in the banking creates field of research in the world today. GP modelling can be used to build up bank risk management model to identify the bank crisis. The first step to identification of risks, potential risk to bank system operating at all level, evaluation, measure and systemization of risk.
- IV. Public and private sector which attracts the attention of researchers and students. Multi-objective programming is a powerful mathematical producer and is applied to wide range of problems in private and public sector. It also applicable in the process of resource allocation such as water resource system, urban transportation planning, educational establishment, hospital, City Corporation are the problems in this area. The rapid expansion of population requires systematic approaches and dynamic planning for efficient resource allocations. Many researchers may studied in these areas.

Looking on the brighter side of criticism of GP modeling will create new opportunities for students and researchers. This additional area for research that can be proposed will help to reverse or interchange some of the negative comments that exists in the study of GP. The development of examples of GP modeling that counter all the defects in the GP modeling that have been reported in the literature over the years is one of the possible future researches.



4. Conclusion

The goal of this paper is to help the students and researchers to identify the relevant applied goal programming problems and will help the researchers to focus on GP models and tools. The goal programming model could be a powerful tool, allowing a collective decision making process and will be a major contribution to the field of OR or MCDM. We envision a future in which GP will continue to utilize methods for the sector of agriculture, management, finance, accounting, engineering and banking etc. Another aim to adopt GP as a school subject of interest and research which enhancing the understanding of newer interactive GP methodologies and use of computers. These newer teaching methods will undouble help to increase the interest in GP in a new generation students. There will be a more than a sufficient body of knowledge in goal programming methodology and applications to support any use of the model that fits its basic assumptions. There is also sufficient computer software which helps in the application of GP in small, medium and large scale problems solving.

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