الجمهورية الجزائرية الديمقراطية الشعبية
Republic Democratic and Popular of Algeria
وزارة التعليم العالي والبحث العلمي
Ministry of Higher Education and Scientific Research

Mohamed Khider University of Biskra
Faculty of Science and Technology
Department of Electrical Engineering
Sector : Electronics
Option : Telecommunications

Ref:............

Memory of End of Studies
With a view to obtaining
Diploma of :

MASTER

Theme

Introduction of Bees' Algorithm for an Intelligent Control of Blood Pressure in Hemodialysis Generator

Presented by:
Bouaiss khaoula

Presented in : 1 June 2014

Front of the jury composed of:

Dr. GUESBAYA Tahar	M.C.A	President
Dr. TOUMI Abida	M.C.B	Supervisor
Mr ABDESSELAM Salim	M.A.A	Examiner

Academic year: 2013 / 2014

الجمهورية الجزائرية الديمقراطية الشعبية
Republic Democratic and Popular of Algeria
وزارة التعليم العالي والبحث العلمي
Ministry of Higher Education and Scientific Research

Mohamed Khider University of Biskra
Faculty of Science and Technology
Department of Electrical Engineering
Sector : Electronics
Option : Telecommunications

Ref:............

Memory of End of Studies
With a view to obtaining
Diploma of :

MASTER

Theme

Introduction of Bees' Algorithm for an Intelligent Control of Blood Pressure in Hemodialysis Generator

Presented by:
Bouaiss khaoula

Presented in : 1 June 2014

Front of the jury composed of:

Dr. GUESBAYA Tahar	M.C.A	President
Dr. TOUMI Abida	M.C.B	Supervisor
Mr ABDESSELAM Salim	M.A.A	Examiner

Academic year: 2013 / 2014

الجمهورية الجزائرية الديمقراطية الشعبية
République Algérienne Démocratique et Populaire
وزارة التعليم العالي والبحث العلمي
Ministère de l'enseignement Supérieur et de la Recherche scientifique

Université Mohamed Khider Biskra
Faculté des Sciences et de la Technologie
Département de Génie Electrique
Filière : Electronique
Option : Télécommunications

Mémoire de Fin d'Etudes
En vue de l'obtention du diplôme:

MASTER

Théme

Introduction of Bees Algorithm for an Intelligent Control of Blood Pressure in Hemodialysis Generator

Présenté par :
BOUAISS khaoula

Avis favorable de l'encadreur :
Nom Prénom *signature*
TOUMI abida

Avis favorable du Président du Jury
Nom Prénom ***Signature***
GUESBAYA Tahar

Cachet et signature

الجمهورية الجزائرية الديمقراطية الشعبية
République Algérienne Démocratique et Populaire
وزارة التعليم العالي والبحث العلمي
Ministère de l'enseignement Supérieur et de la Recherche scientifique

Université Mohamed Khider Biskra
Faculté des Sciences et de la Technologie
Département de Génie Electrique
Filière : Electronique
Option : Télécommunications

Theme

Introduction of Bees Algorithm for an Intelligent Control of Blood Pressure in Hemodialysis Generator

Proposé et Dirigé par : Dr. Toumi Abida

Abstract

Bees Algorithm (BA) is a population-based algorithm inspired by the honey bees forage for food. The algorithm presents a neighborhood search associated with a random search which can be used for optimization problems. In this study, we, first, deal with the presentation and simulation of the Artificial Bees' Algorithm. After, we use the BA for tuning the PID controller that was proposed to control the blood pressure in hemodialysis generator. Comparing with a classic PID controller the proposed controller provides high performances like negligible overshoots and fast responses.

ملخص

خوارزمية النحل هي خوارزمية تقوم على أساس الحياة الجماعية و هي مستوحاة من طريقة جمع النحل للطعام. إن خوارزمية البحث، هذه، مرتبطة بالبحث العشوائي الذي يمكن استخدامه في الحصول على الحل الأمثل لمسائل التحسين . في هذه الدراسة سوف نقوم، أولا، بعرض و محاكاة خوارزمية النحل الاصطناعي. بعد ذلك، نستعمل الخوارزمية لضبط وحدة التحكم المقترحة للتحكم في ضغط الدم لجهاز تصفية الدم. بالمقارنة مع الضابط PID الكلاسيكي، الضابط المقترح يوفر أداءات عالية مثل التجاوزات الضئيلة و الاستجابات السريعة.

Dedication

This thesis is honestly dedicated to my beloved

Parents,

My grandmother. Omhani,

Sisters: Selma and ibtissam,

My relative: Imen,

Friends: Samah, Hassiba, Soumia, Hakima, Sarah,

All the members of my family

All my best companions in life.

Acknowledgment

I would like to thank God for his blessing and guidance in the process of completing this research work.

First, I wish to express my sincere gratitude to my beloved parents, my sisters who have patiently given their moral support, advice and prayers for me so that I can finish my study.

I would like to thank my supervisor, Dr. toumi abida, who shared me his ideas and offered his time and helpful comments during this stressful period.

My thanks also go to :

- ✓ *All my classmates*
- ✓ *All the teachers of the Branch of Electronic especially those who offered us some of their time.*

Summary

Chapter I : Bees algorithm

Chapter II : Hemodialysis

Chapter II : Simulation results

Liste of figure

Liste of figure

ASIN	Analog	Signal	Input	
ASOT	Analog	Signal	Output	
BYPH	Bypass	Heater		
CCI1	Conductivity	Control	I1	
CCI2	Conductivity	Control	I2	
CDVA	Chemical	Disinfection	Valve	
CGI1	Conductivity	Guard	I1	
CGI2	Conductivity	Guard	I2	
CGU1	Conductivity	Guard	U1	
CGU2	Conductivity	Guard	U2	
DIVA	Dialysate	Valve		
DML1-4	Dosage	Motor	Winding	1-4
FLPC	Flow	Pump	Current	
FLPV	Flow	Pump	Voltage	
FPTS	Flow	Pressure	Transducer	Signal
FSVA	Flow	Stop	Valve	
HEN 1	Heating	Element	N° 1	
HEN 2	Heating	Element	N° 2	
HPGC	High	Pressure	Guard	Switch

Liste of signaux

INVA	Intel	Valve		
NPPC	Negative	Pressure	Pump	Current
NPPV	Negative	Pressure	Pump	Voltage
NPTS	Negative	Pressure	Transducer	Signal
REVA	Reserve	Valve		
SAGE	Safety	Guard	Switch	
TECA	Temperature	Control		
TEGA	Temperature	Guard		
WVHL	Water	Vessel	High	Level
WVLL	Water	Vessel	Low	Level
WVSM	Water	Vessel	Stirring	Motor
MmHg			MILLIMETER Hydrargyrum	

General Introduction

In our work, we study the bees algorithm which is one of the smart algorithms.This algorithm mimics the behaviour of groups of bees during the process of prospecting for food. The process of prospecting for food “foraging behaviour” among groups of bees is an inherently vital behaviour. It serves as a necessary element for food, life and progress and it considered as one of the more complex behaviors. Through it, groups of bees can spread across vast areas and distances sometimes exceeding 14 kilometers in different directions for finding the largest number of food sources.

Food foraging behaviour determines the fate of the bee hive and achieves the growth and survival of the groups that succeed to select the most suitable places that are covered with flowers rich with nectar and pollen form the perfect food for bees. The process begins with the selection of a certain type of bees named Scout bees to be responsible to find good spaces rich of food. The scout bees move at random from an area to another .During the harvest season, more scout bees are sent and when they return to the hive, the bee that finds the best space with high quality in terms of containing a larger amount of food put the amount of nectar in a specific location and then goes to another place called the field of dance (Dance floor).. That dance is to give a kind of report on the place it has visited and to inform the group about the size of the area discovered, without the need for any map. Therefore, the group decide the best place to be explored according to what it received from the report of the Scout bees.

This complex behavior has inspired large number of scientists and researchers to devise innovative ways to solve some complex problems. The first of them were the scientists Luis and Teodorovi who were the pioneers to use the collective intelligence primary principles of groups of bees in solving the combinatorial optimization such as the problem of travelling salesman. Research continues to make a progress in the different fields of technology: Neural Network training for pattern recognition, machine task scheduling, data clustering, and Computer vision and pattern recognition. All of these uses prove and confirm the progress of artificial intelligence in different new directions.

What we intend to do is the enforcement of the use of this algorithm in the medical field to control blood pressure in hemodialysis machine.

In the first chapter, the Behaviour of Bees in Nature, Bees colony algorithm and their application will be presented. In our case we use the Bees algorithm to optimize the pressure in hemodialysis machine.

In the second chapter, we describe the biological kidneys, dialysis definition and function principle, blood flow and hemodialysis generators and their specifications.

Finally, in the third chapter simulation results of our system with comparing between our ABC-PID proposed controller and PID controller. The simulation results prove the robustness of our proposed controller.

Chapter 1

Bees Algorithm

I.1. Introduction

Swarm Intelligence has been evolving as an active area of research over the past years. The major emphasis is to design adaptive, decentralized, flexible and robust artificial systems, capable of solving problems through solutions inspired by the behavior of social insects. Research in the field has largely been focused on working principles of ant colonies and how to use them in the design of novel algorithms for efficiently solving combinatorial optimization problems.

To our knowledge, little attention has been paid in utilizing the organization principles in other swarms such as honey bees to solve real world problems although the study of honey bees has revealed a remarkable sophistication of the communication capabilities as compared to ants. Nobel laureate Karl von Frisch deciphered and structured these into a language, in his book The Dance Language and Orientation of Bees. Upon their return from a foraging trip, bees communicate the distance, direction, and quality of a flower site to their fellow foragers by making waggle dances on a dance floor inside the hive. By dancing zealously for a good foraging site, they recruit foragers for the site. In this way a good flower site is exploited, and the number of foragers at this site is reinforced. We model bee agents in packet switching networks, for finding suitable paths between sites, by extensively borrowing from the principles behind the bee communication [1].

I.2. History

The Bees Algorithm is a new population-based search algorithm, first developed in 2005 by Pham et al. [2], [3] have proposed the Bees Algorithm which that mimics the food foraging behavior of swarms of honey bees. In its basic version, the algorithm performs a kind of static neighborhood sampling combined with static random sampling. The Bees algorithm starts with the scout bees being placed randomly in the search space. The fitness of the scout bees is evaluated, after which, the bees that have the highest fitness are chosen as “selected bees” and sites visited by them are chosen for static neighborhood sampling. The algorithm takes samples in the neighborhood of the selected sites by placing bees in them, taking more samples near the best sites. For each site only the bee with the highest fitness is selected to form the next bee population. The remaining bees are used for random sampling. These steps are repeated until a stopping criterion is met independently. In its basic version, the algorithm performs a kind of neighborhood search combined with random search and can be used for optimization problems, and makes it possible for research scientists and engineers to solve complex problems involving vast amounts of data, categorizing the results according to specific criteria (such as geographic region or age group), and then giving priority to the results most likely to yield workable solutions. Computers and swarms of insect robots can use the bees algorithm as well [4].

I.3. Description of the Behaviour of Bees in Nature

Social insect colonies can be considered as dynamical system gathering information from environment and adjusting its behaviour in accordance to it. While gathering information and adjustment processes, individual insects do not perform all the tasks because of their specializations. Generally, all social insect colonies behave according to their own division labours related to their morphology. Bee system consists of two essential components:

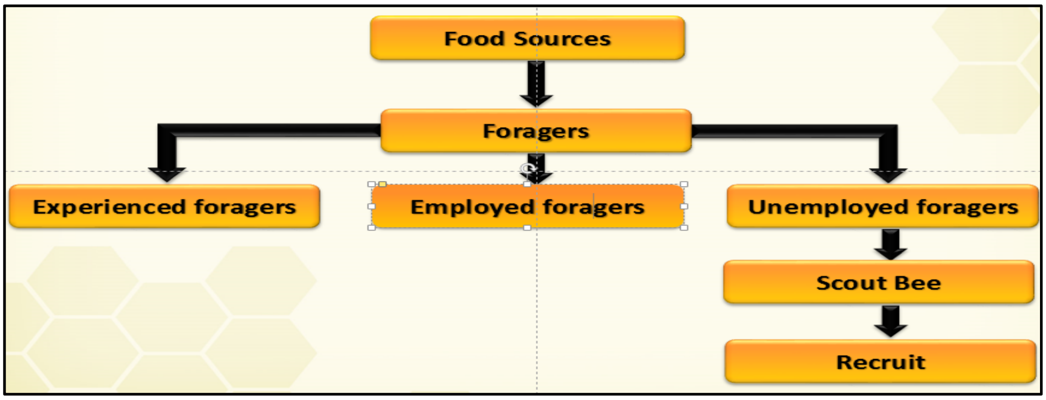

Figure I.1. Diagram the Behaviour of Bees in Nature

• Food Sources:

The value of a food source depends on different parameters such as its proximity to the nest, richness of energy and ease of extracting this energy.

• Foragers

a. Unemployed foragers: If it is assumed that a bee has no knowledge about the food sources in the search field, bee initializes its search as an unemployed forager. There are two possibilities for an unemployed forager:

• Scout Bee (S in Figure I.2): If the bee starts searching spontaneously without any knowledge, it will be a scout bee. The percentage of scout bees varies from 5% to 30% according to the information into the nest. The mean number of scouts averaged over conditions is about 10% (Seeley, 1995).

• Recruit (R in Figure I.2): If the unemployed forager attends to a waggle dance done by some other bee, the bee will start searching by using the knowledge from waggle dance.

b. Employed foragers (EF in Figure I.2): When the recruit bee finds and exploits the food source, it will raise to be an employed forager who memorizes the location of the food source. After the employed foraging bee loads a portion of nectar from the food source, it returns to the hive and unloads the nectar to the food area in the hive. There are three possible options related to residual amount of nectar for the foraging bee:

• If the nectar amount decreased to a low level or exhausted, foraging bee abandons the food source and become an unemployed bee.

• If there are still sufficient amount of nectar in the food source, it can continue to forage without sharing the food source information with the nest mates

• Or it can go to the dance area to perform waggle dance for informing the nest mates about the same food source. The probability values for these options highly related to the quality of the food source.

c. Experienced foragers: These types of foragers use their historical memories for the location and quality of food sources.

• It can be an inspector which controls the recent status of food source already discovered.

• It can be a reactivated forager by using the information from waggle dance. It tries to explore the same food source discovered by itself if there are some other bees confirm the quality of same food source (RF in Figure I.2).

• It can be scout bee to search new patches if the whole food source is exhausted (ES in Figure I.2).

• It can be a recruit bee which is searching a new food source declared in dancing area by another employed bee (ER in Figure I.2) [5].

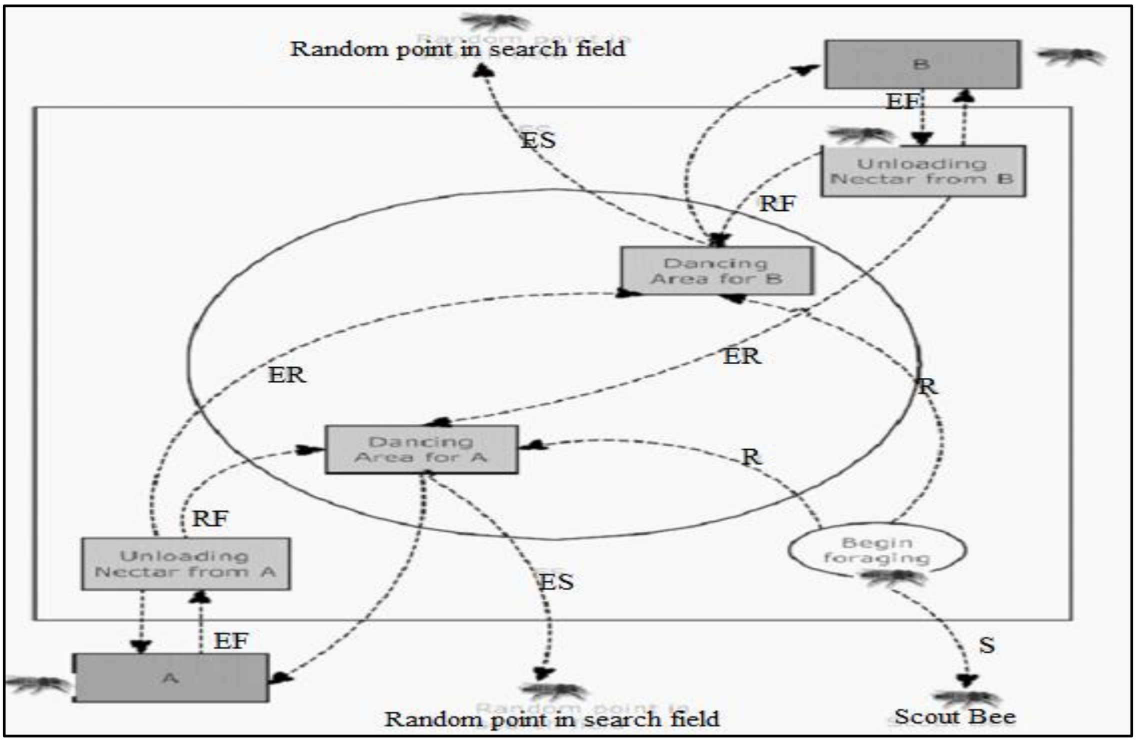

Figure I.2. Typical behaviour of honey bee foraging

I.4. The Dance Language of Bees

I.4.1 Describing the Dance Language:

1. "Round Dance"

=> When food source is < 50 meters from hive

2. "Waggle dance"

=> When food source is > 50 meters away

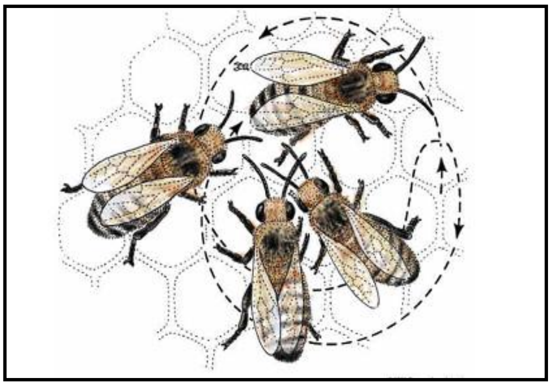

Figure I.3. Round Dance

1. Angle between vertical & waggle run =angle between sun & food source

2. Dance "tempo" (slower = farther)

3. The duration of the dance (longer =better food)

4. Short stops in which the dancer doles out samples of the food to her audience

5. Other bees follow the dancer ("audience")

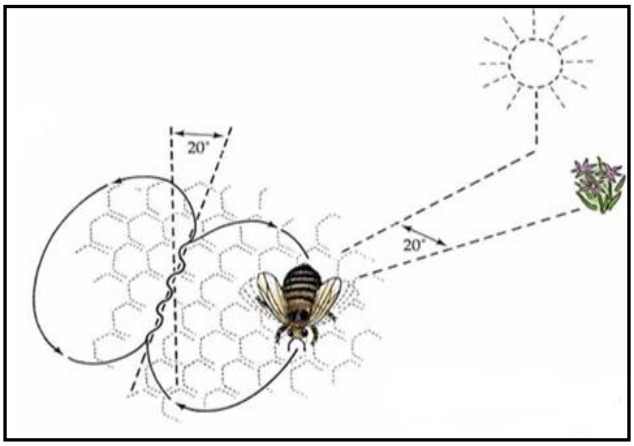

Figure I.4. Waggle dance

SCOUT: finds new food sources & dances

RECRUITS: follow dances & then forage

Austrian ethologist Karl von Frisch was one of the first people to translate the meaning of the waggle dance.

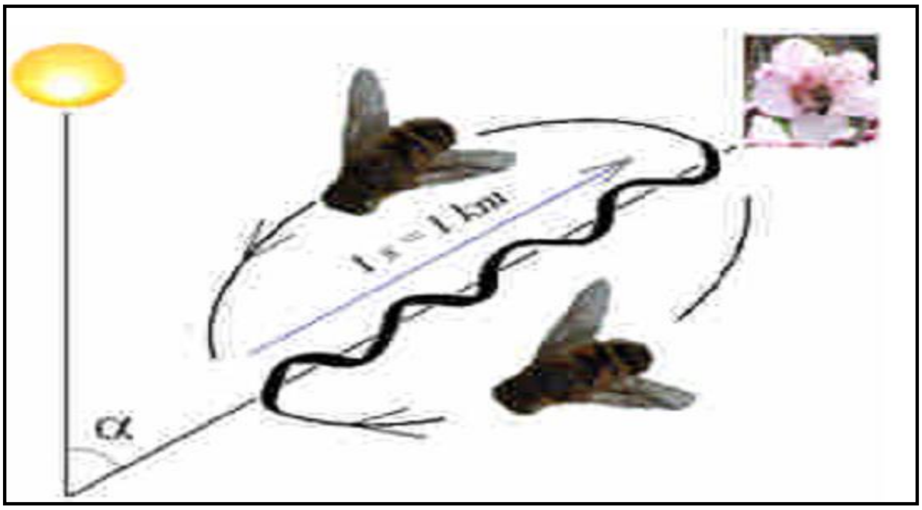

Figure I.5. The distance between hive and flowers is shown in the duration of the waggle dance

The distance between hive and flowers is shown in the duration of the waggle runs. The farther the flowers are from the hive, the longer the waggle phase. For every 100 meters the flowers are distant from the hive, the waggle phase lasts about 75 milliseconds. [6]

I.5. Review and Categorization of Studies on Artificial Bee Systems

The foraging behaviour, learning, memorizing and information sharing characteristics of bees have recently been one of the most interesting research areas in swarm intelligence. Studies on honey bees are in an increasing trend in the literature during the last few years. After a detailed literature survey, the previous algorithms are categorized in this work by concerning the behavioral characteristics of honey bees which are: [5].

- Foraging behaviours
- Marriage behaviours
- Queen bee concept

I.6. BEES ALGORITHM

I.6.1 The Basic Bees Algorithm

This main step of the basic Bees algorithm as stated in the Bees Algorithm is one of optimisation algorithms, which are inspired by the natural foraging behaviour of honey bees. Figure (I.3) shows the simplest form of the pseudo code of the algorithm. The algorithm starts with initial population (scout bees) which is generated randomly, and then the BA search process is started until the stopping criterion is met [7].

Initialize population with random
Solutions.

Evaluate fitness of the population.

While (stopping criterion not met)

//Forming new population.

Select sites for neighborhood search.

Recruit bees for selected sites (more bees

for best e sites) and evaluate fitness.

Select the fittest bee from each patch.

Assign remaining bees to search randomly

and evaluate their fitness.

End While.

Figure I.6. Original Bees algorithm

In first step, the scout bees that have the highest fitness are chosen as “selected bees” and sites (solutions) visited by them are chosen for neighborhood search. Then, the algorithm performs the search in the neighborhood of the selected sites, assigning more bees to search near to the best sites. The bees can be chosen directly according to the fitness associated with the sites they are visiting. The remaining bees in the population are assigned randomly around the search space scouting for new solutions. At the end of each iteration, the colony will have two parts for its new population. The first part will contain the representatives from each selected sites (selected solutions), and the second part will contain other scout bees assigned to conduct random searches [7].

I.6.2 The Bees Algorithm

Figure I.6 presents the pseudo-code of our approach. The algorithm starts with feasible initial solutions generated using a graph coloring heuristic to form an initial population. The size of the population is equal to the number of the scout bees (ns). Each scout bee evaluates the solution using the fitness function

$$P_i = \frac{fi}{\sum_{n=1}^{SN} fi} \quad (I.1)$$

Where SN = number of food sources, fi= fitness function of the i^{th} food source [7].

```
Initialization:
Initialize the initial population and Calculate the fitness values;
Set best solution, Solbest;
Set maximum number of iteration, NumOfIte;
Set the population size, PopSize;
Set ne: number of elite solutions;
Set nre: recruited bees for elite solutions;
Set nb: number of best solutions;
Set nrb: recruited bees for remaining best
solutions;
Set stlim: limit of stagnation cycles for the
abandonment solutions;
iteration ← 0;
Improvement:
do while (iteration < NumOfIte)
for i=1: popsize
Scout bees evaluate the solutions;
Calculate the probability value, Pi;
Rank the solutions based on Pi
(For basic BA use the fitness value to rank
the solutions)
end for
nbSet ← Select the top nb solutions from the
population;
neSet ← Select the top ne solutions from the
nbSet;
for j=1: nrb
for h=1: nb
Sol* ← neSeth;
Apply random neighbourhood on Sol*;
Update the population by the Improved
solutions;
end for
end for
for j=1: nre
for h=1: ne
Sol* ← neSeth;
Apply random neighbourhood on Sol*;
Update the population by the Improved
solutions;
end for
end for
recruit the remaining bees for random search
Solbest ← best solution found so far;
iteration++;
end do
```

Figure I. 7. The pseudo code for the Bees algorithm

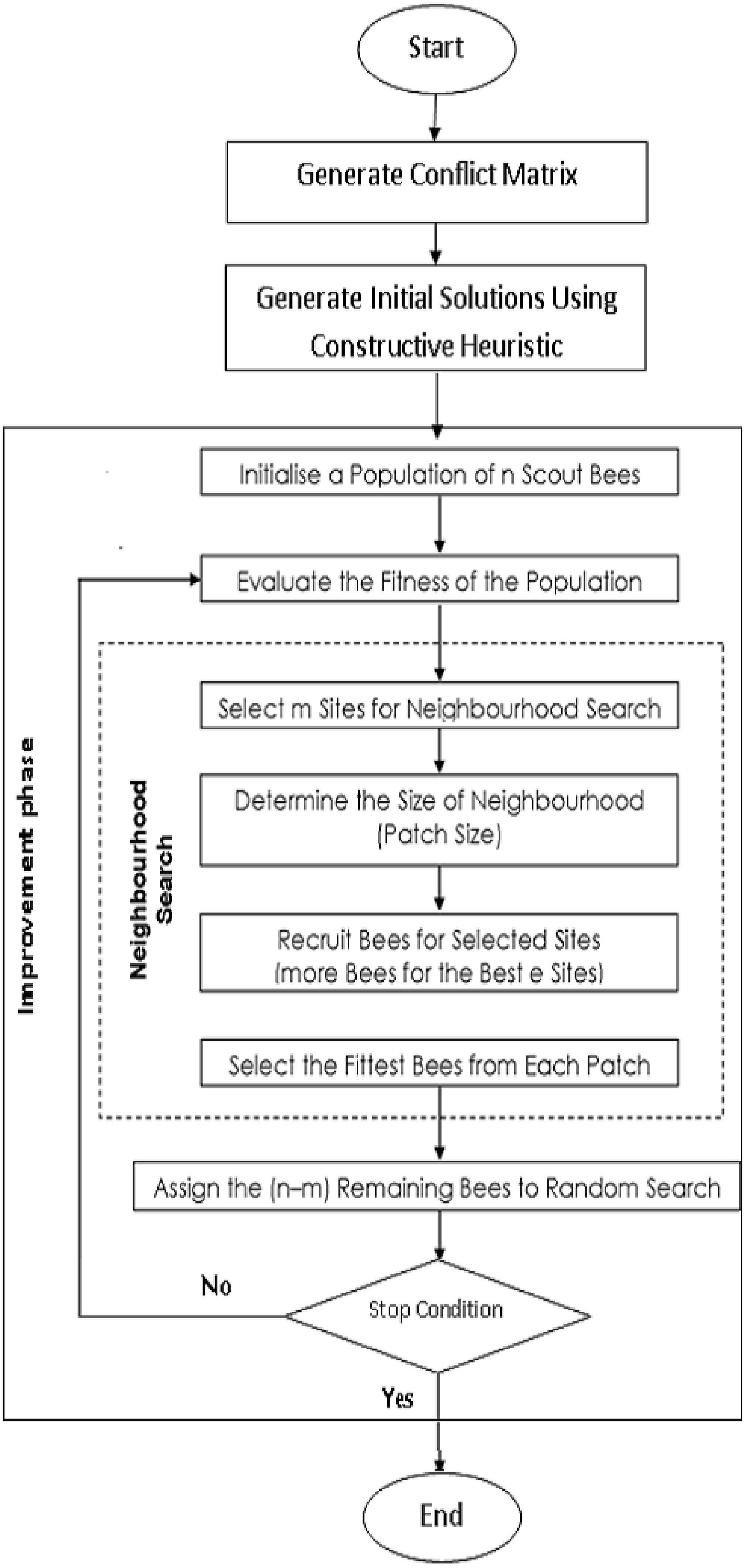

Figure I. 8. The Block Diagram for the Algorithm

I.6.3 Or-opt Algorithm

Or-opt algorithm was proposed by the or in 1976. It attempts to improve the current route by moving one or two consecutive points or three consecutive points in a different location until the original route was further improved or satisfy the maximum cycle number. For example, we had five points (a, b, c, d, e) and they formed Hamilton cycle as figure (I.9-A). If we wanted to improve path of figure (I.9-A), we selected a point assume that is d, changed the front and rear of point d connection for forming a new path as figure (I.9-B).

Food source in the population and each food source are generated as follows:

$$X_{i,j} = X_{min,j} + random(0,1)(X_{max,j} - X_{min,j}) \qquad \text{(I.2)}$$

where i=1,2,…,SN and SN is the number of food sources and j=1,2,…,n is the dimension index of the problem and$\boldsymbol{X_{max,j}}$and $\boldsymbol{X_{min,j}}$ are upper bound and lower bound respectively.

After initialization, the population is evaluated fitness value fit as the following:

$$fit = \begin{cases} \frac{1}{1+f_i} & if \ \ f_i \geq 0 \\ 1 + abs(f_i) & if \ \ f_i < 0 \end{cases} \qquad \text{(I.3)}$$

Where $f_i$that is $\boldsymbol{X_{i,j}}$ is substituted object function to get the value. In the employed bees phase, each employed bee generates a new food source Vi in the neighborhood of its present position. The formulation will be as follows:

$$v_{ij} = x_{ij} + \phi_{ij}(x_{ij} - x_{kj}) \qquad \text{(I.4)}$$

where k=1,2,3,…,SN and j=1,2,3,…,n and k and j are mutually different random integer indices selected from {1,2,…,SN}.ϕ_{ij} is a random number in the range [-1,1]. Once V_i is obtained, it will be evaluated fitness value and be compared toX_i. If the fitness value of the new solution is better or equal than the old ones, V_i will replace X_i and become a new member of the population, otherwise X_i is retained. After employed bees phase, the probability value was calculated based on the fitness of the food sources as the following [8].

$$P_i = \frac{fi}{\sum_{n=1}^{SN} fi} \qquad \text{(I.1)}$$

In the onlooker bees phase, the onlooker bees evaluate the nectar information taken from all the employed bees and select a food sourceX_i depending on its probability value. Once X_i has selected, the onlooker bees generate a modification on X_i by using (I.4). If the modified food source is better or equal than X_i, the modified food source will replace$X_i$and become a new member of the population. In the scout bees phase, if a food source X_i cannot be improved by a predetermined number of trials, X_i is abandoned. The scout bees generate a food source randomly by using (I.2).

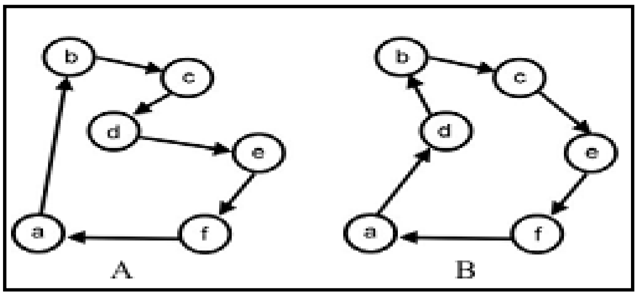

Figure I.9. Or-opt algorithm

I.7. Application Bees Algorithm

Many fields of application algorithms bees include:

- The optimization function.
- The resolution of the traveling salesman problem (TSP), which was made by Lucic and Teodorovic and gave very good results.
- Clustering of data.
- Robot control.
- The scheduling of tasks.
- The prediction of protein structure.
- Electronic and mechanical design. [9]

I.8. CONCLUSION

The meta-heuristic Bee Colony optimization is inspired by the foraging behaviour of honey bees. It represents a general algorithmic framework relevant to various optimization problems in management, engineering, and control, and it could always be tailored for a specific problem. The bee method is based on the concept of cooperation, which increases the efficiency of artificial bees and allows achievement of goals that could not be reached individually. The bee has the capability, through the information exchange and recruiting process, to intensify the search in the promising regions of the solution space. When it is necessary, the bee can also diversify the search: The freedom to make an individual decision constitutes that diversifying element.

The bee has already been effectively applied to some combinatorial optimization problems, and we hope that extended application reports are to come quickly. Additionally, the appropriateness for parallelization of the bee algorithm opens not only a new research direction but also some new possible applications. On the other hand, the bee has not been extensively used for solving real-life problems and theoretical results supporting bee concepts are still absent. That is the necessary work in the forthcoming research. Based on the achieved results and gained experience, new models founded on bee principles (autonomy, distributed functioning, self-organizing) are expected to significantly contribute to solving complex engineering, management, and control problems. Until now, the most important direction of the future research is the mathematical validation of the bee approach. In years to come, the authors expect more bee based models, examining, for in-stance, bees' homogeneity (homogenous vs. heterogeneous artificial bees), various information sharing mechanisms, and various collaboration mechanisms. [10]

Chapter 2

Hemodialysis

II.1. Introduction

Hemodialysis remains the major modality of renal replacement therapy. Since the 1970s the drive for shorter dialysis time with high urea clearance rates has led to the development of high-efficiency hemodialysis. In the 1990s, certain biocompatible features and the desire to remove amyloidogenic microglobulin have led to the popularity of high-flux dialysis. During the 1990s, the use of high-efficiency and high-flux membranes has steadily increased and the use of conventional membrane has declined. In 1994, a survey by the Centers for Disease Control showed that high-flux dialysis was used in 45% and high-efficiency dialysis in 51% of dialysis centers. Despite the increasing use of these new hemodialysis modalities the clinical risks and benefits of high-performance therapies are not well defined. In the literature published over the past 10 years the definitions of high-efficiency and high-flux dialysis have been confusing. Currently, treatment quantity is not only defined by time but also by dialyzer characteristics, *i.e.* blood and dialysate flow rates. In the past, when the efficiency of dialysis and blood flow rates tended to be low, treatment quantity was satisfactorily defined by time. Today, however, treatment time is not a useful expression of treatment quantity because efficiency per unit time is highly variable. [11]

II.2. Biological kidneys

The kidneys are bean-shaped organs. Each is about 4 to 5 inches (12 centimeters) long and weighs about one third of a pound (150 grams). One lies on each side of the spinal column, just behind the abdominal cavity, which contains the digestive organs. Each kidney receives blood through a branch of the aorta, called the renal artery. Blood flows from the renal artery into progressively smaller arteries, the smallest being the arterioles. From the arterioles, blood flows into glomeruli, which are tufts of microscopic blood vessels called capillaries. Blood exits each glomerulus through an arteriole that connects to a small vein. The small veins join to form a single large renal vein, which carries blood away from each kidney.

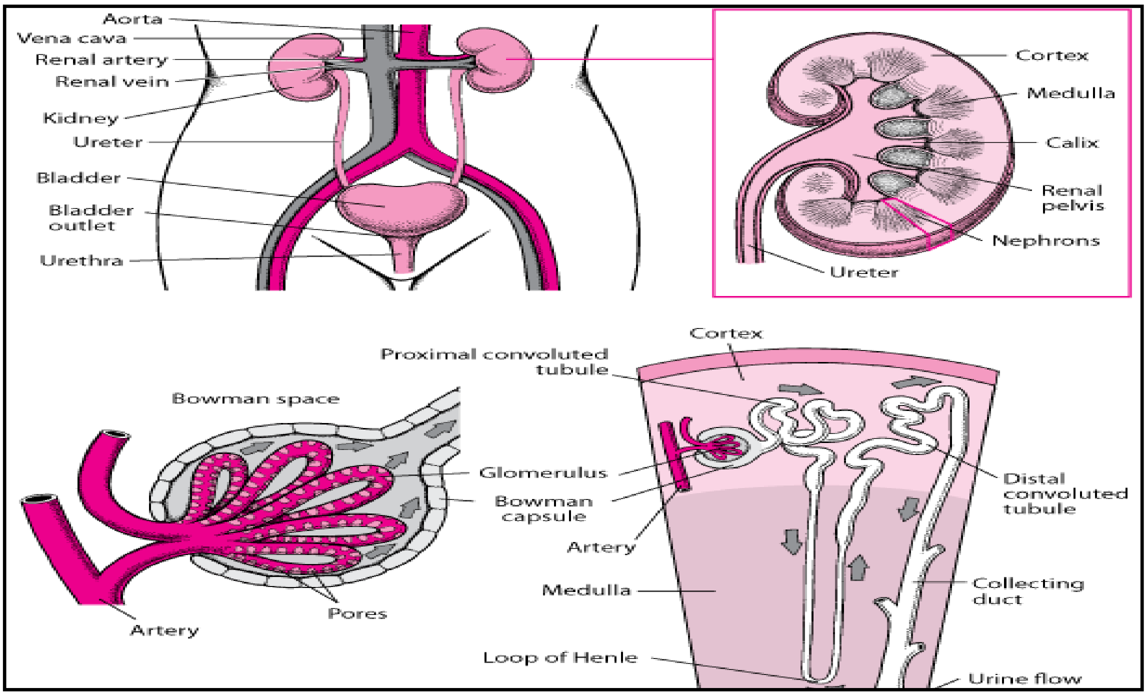

Figure II.1. The Urinary Tract

Nephrons are microscopic units that filter the blood and produce urine. Each kidney contains about one million nephrons. Each nephron contains a glomerulus surrounded by a thin-walled, bowl-shaped structure (Bowman capsule). Also in the nephron is a tiny tube (tubule) that drains fluid (now considered urine) from the space in Bowman capsule (Bowman space). A third part of the nephron is a collecting duct that drains urine from the tubule. Each tubule has three interconnected parts: the proximal convoluted tubule, the loop of Henle, and the distal convoluted tubule.

The kidneys consist of an outer part (cortex) and an inner part (medulla). All glomeruli are located in the cortex, while tubules are located in both the cortex and the medulla. The urine drains from the collecting ducts of many thousands of nephrons into a cuplike structure (calix). Each kidney has several calices, all of which drain into a single central chamber (renal pelvis). Urine drains from the renal pelvis of each kidney into a ureter.

II.3. Functions of the Kidneys

All of the functions normally done by two kidneys can be carried out adequately by one healthy kidney. Some people are born with only one kidney and others choose to donate one kidney for transplantation into another person with kidney failure. In other cases, one kidney may be severely damaged by disease or injury.

The primary function of the kidneys is to maintain the proper balance of water and minerals (including electrolytes) in the body. An additional function is filtration and excretion of waste products from the processing of food, drugs, and harmful substances (toxins). Kidneys also regulate blood pressure and secrete certain hormones. [12]

II.4. Blood and Nerve Supply of the Kidney

- Because the kidney filters blood, its network of blood vessels is an important component of its structure and function.
- The arteries, veins, and nerves that supply the kidney enter and exit at the renal hilum.
- Renal Plexus: the kidney and nervous system communicate via the renal plexus, whose fibers course along the renal arteries to reach each kidney.
- Input from the sympathetic nervous system triggers vasoconstriction in the kidney, thereby reducing renal blood flow.
- Thus, pain in the flank region may actually be referred pain from the corresponding kidney.
- The renal veins drain the kidney and the renal arteries supply blood to the kidney.[13]

II.5. Chronic kidney failure

Chronic renal disease, or chronic kidney disease, is a slow progressive loss of kidney function over a period of several years. Eventually the patient has permanent kidney failure. Chronic kidney failure is much more common than people realize, and often goes undetected and undiagnosed until the disease is well advanced and kidney failure is imminent. It is not unusual for people to realize they have chronic kidney failure only when their kidney function is down to 25% of normal.

As kidney failure advances and the organ's function is seriously impaired, dangerous levels of waste and fluid can rapidly build up in the body. [14]

- The two main forms are acute kidney injury, which is often reversible with adequate treatment, and chronic kidney disease, which is often not reversible.
- Other factors that may help differentiate acute kidney injury from chronic kidney disease include anemia and the kidney size on ultrasound.
- Chronic kidney disease generally leads to anemia and small kidney size.

- Chronic kidney disease (CKD) can also develop slowly and, initially, show few symptoms.
- Acute kidney injuries can be present on top of chronic kidney disease, a condition called acute-on-chronic renal failure (AoCRF). [12]

Treatment is aimed at stopping or slowing down the progression of the disease - this is usually done by controlling its underlying cause.

If chronic kidney failure ends in end-stage kidney disease, the patient will not survive without dialysis (artificial filtering) or a kidney transplant. [14]

II.6. Dialysis

II.6.1 Definition and principle

Hemodialysis is to use media to purify the body of water and accumulated toxic substances when natural kidney is unable to perform this function.

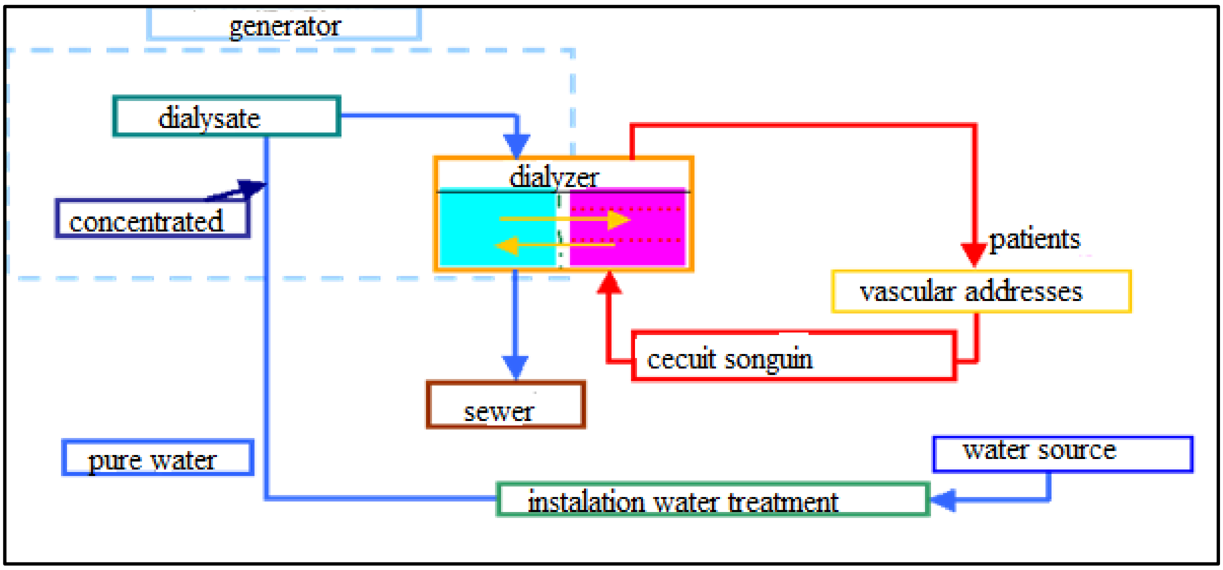

Figure II.2. The principle of hemodialysis is contacting the patient's blood with a liquid fixed composition (dialysate)

This explicit scheme clearly the principle of hemodialysis is contacting the patient's blood with a liquid fixed composition (dialysate), the Fluid 2 compartments separated by a semipermeable membrane.

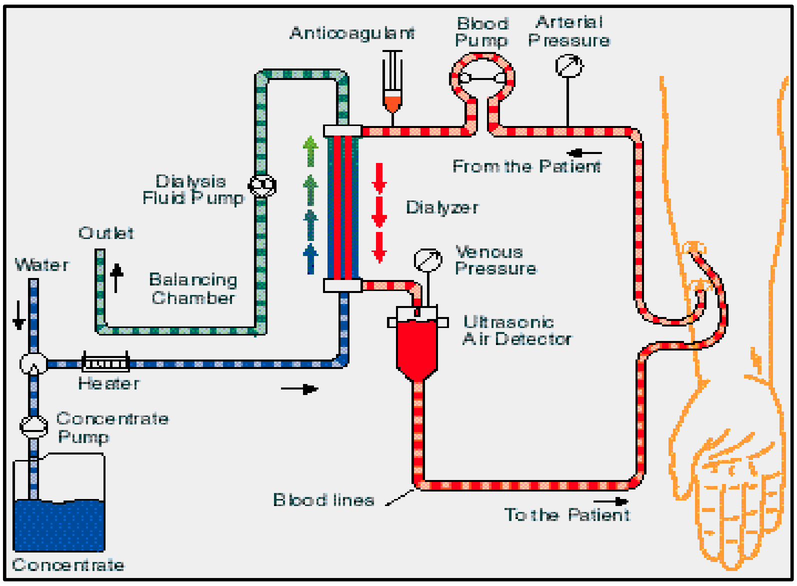

Figure II.3. Principle of hemodialysis

A dialysis session lasts four hours. The term is primarily a function of the weight the patient must lose, but also to remove ionic components. In general, three sessions per week are necessary, sometimes two enough (rare). The sessions take place in specialized centers heavy (Hospitals, clinics or associative centers) in autodialysis Centre (private or voluntary) or at home after learning. [15]

II.6.2 Dialysis Process

Concerning the blood, dialysis performs two different functions that are normally done by healthy kidneys:

1. Removing excess fluid.
2. Removing waste like urea, and excess electrolytes (chemicals) like potassium, magnesium, sodium, etc.

The dialysis is performed inside the dialyzer, which is a plastic cylinder, in which the blood enters from the top (the red header), flows through thousands of extremely thin hollow fibers and leaves from the bottom. At the same time the dialysate enters from the bottom (the blue header), flows around and in between the fibers, and leaves from the top.

The fibers are semi permeable membranes, that is, smaller molecules in the blood stream can pass through them into the dialysate and bigger molecules as well as blood cells cannot. The dialysate is a water-based solution and its purpose is to absorb from the blood all that should be removed and nothing else.

Wastes and electrolytes move from the blood into the dialysate because their concentration in the blood is higher. This process is called diffusion.

The dialysate flow ensures that fresh dialysate is present at all times so that the dialysate does not become saturated and the process never ends. Fluid is removed from the blood in the same way the kidneys do it - by blood pressure. This process is called Ultra Filtration (UF) and is similar to Reverse Osmosis (RO). With RO, the membrane pore size is very small and allows only water to pass through the membranes.

In UF, the membrane pore size is larger, allowing some bigger molecules to pass through the pores with the water. The rate at which fluid is removed from the blood is called UFR (UF Rate). There is higher pressure in the blood passing through the dialyzer and lower pressure in the dialysate. This pressure difference is called TMP (Trans Membrane Pressure). The higher the TMP is, the higher the UFR.

As one can see, the dialyzer is doing the job of dialysis. The rest of the machine takes care of supplying the bloods and the dialysate to the dialyzer, controls the flow and the pressures, and provides visual indication and alarm when something goes wrong. [16]

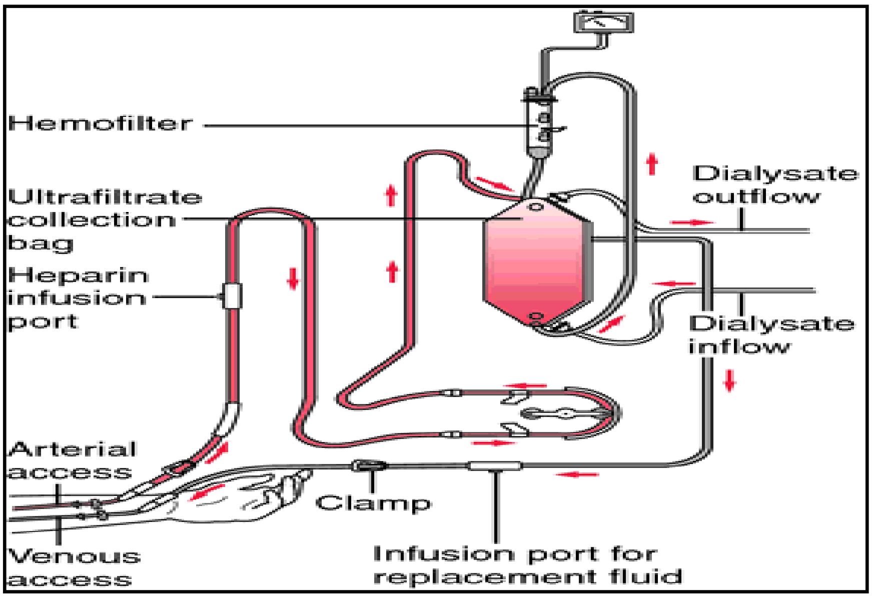

Figure II.4. A hemodialysis circuit

II.7. Blood Flow

The blood pump takes and returns the blood from the patient via the arterial and venous needles. The blood is confined to the disposable plastic tubing and does not come in contact with any part of the machine. The blood pump is the distinct feature on all dialysis machines. The pumping is done by squeezing the plastic tube inside the pump using a pair of spring loaded rollers. The suction is done by the elasticity of the tube, which expands after released from the rollers and sucks the blood from the arterial needle.

The blood coming from the pump flows to the dialyzer and the blood that leaves the dialyzer returns to the patient through the venous needle. The pump speed, and the resulting blood flow rate, is adjustable from zero to about 600 cc/min. While pump speed is controlled, blood flow rate is displayed. These two usually go hand in hand, but not always.

The machine controls the pump speed, so this is the only information that it knows for sure. The blood flow rate is calculated and based on the pump RPM (revolution per minute), and the diameter of the tube, entered by a screwdriver driven selector in the pump. The calculated blood flow is displayed. The control does not check the real blood flow. It displays blood flow even if the pump turns without the plastic tube installed. [16]

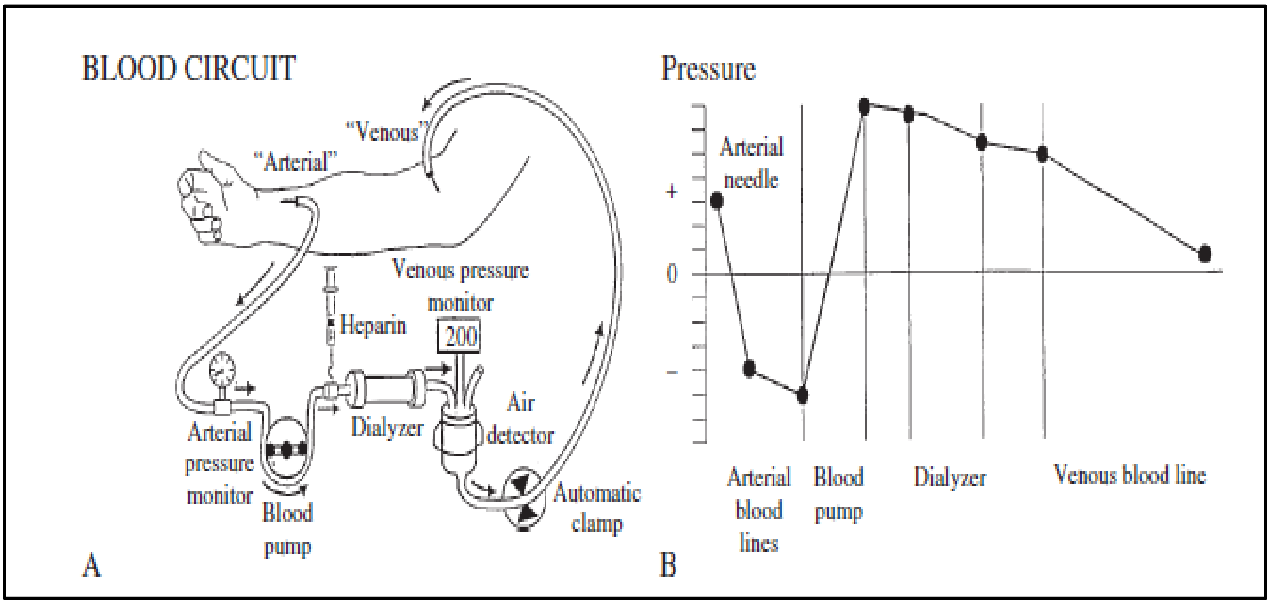

Figure II.5. Operation of an artificial kidney

II.7.1 Arterial Pressure Monitor (prepump)

This component monitors the pressure between the blood access and the blood pump. The pressure is negative between the access and the blood pump (Figure II.5.B) but achieves a high positive range post-blood pump (Figure II.5.B). the pressure transducer signal is amplified and converted to an electrical signal. Alarms may indicate patient disconnection, separation of blood tubing, or obstruction/kink in the blood circuit. The normal pressure reading in this segment of the blood circuit is negative (subatmospheric). Negative pressure makes this segment prone to entry of air into the bloodstream. Longer needles with smaller bores increase negative pressure readings in this segment. Likewise, negative-pressure augmentation may be seen when longer catheters with smaller internal diameter bores are used, especially with higher blood flows. Out-of-range pressures trigger the machine to clamp the blood line and activate the appropriate alarms.

- Causes of low arterial pressure alarm:
  - ✓ Fall in blood pressure ;
  - ✓ Kink between needle and pump;
  - ✓ Clot (check for air bubbles); and
  - ✓ Suction of vessel wall into the needle.
- Causes of a high arterial pressure alarm:
  - ✓ Increase in patient's blood pressure;
  - ✓ Circuit disruption between access and pump;
  - ✓ Unclamping of saline infusion line; and
  - ✓ Blood pump that has torn the pumping segment (check for blood leak).

II.7.2 Venous Pressure Monitor (postdialyer)

The venous pressure may build up owing to resistance to venous return anywhere between the venous drip chamber and the venous needle (together with the access pressure). Venous pressure monitors normally read positive pressures. Out-of-range pressures trigger clamping of the blood line, stopping of the blood pump, and activation of appropriate alarms, with shutting of the venous return.

- Causes of a low venous pressure alarm:
  - ✓ Disruption of connections anywhere down Stream from the blood pump to and including the venous needle and access ; and
  - ✓ Low blood flow (up Stream of blood pump).

- ✓ Causes of a high venous pressure alarm (high venous pressure may rupture the dialyzer membrane!)
- ✓ Kink in the venous return line ;
- ✓ Clot in the venous drip chamber ; and
- ✓ Venous access malfunction. [17]

II.7.3 Blood pump

Blood is pumped in the circuit by peristaltic action at a rate of 200 to 600 mL/min. The pump usually has two rollers (roller rotation compresses the tubing, thus forcing blood along the tube), operating on a low-voltage motor (less electrical hazard). The blood pump is spring-loaded to prevent under-/overocclusion of the blood tubing (the pump segment of the tubing is made up of thicker and more resilient material). The pump is adaptable to different sized tubing if indicated clinically and can be operated manually in the event of a power loss. It is calibrated to measure blood flow rate (BFR) depending on the internal diameter of the tubing : BFR = rpm (measured directly) *tubing volume (Pi * r2 * 1), where r is the internal radius of the tubing and lis the length of the tubing being compressed between the two rollers. Owing to limited rigidity, the tubing between the two rollers flattens with a high negative pressure and the and the above formula overestimates the blood flow at high BFR.

II.7.4 Requirements for air detector

- Should preferably be ultrasound (US)-based (detects change in US frequency caused by air foam).
- Should respond to air in blood, blood and saline, or saline alone. Because fluids transmit sound more efficiently, a drop in the intensity of US indicates presence of air bubbles (rate of transmission of US : blood > saline > air).
- Must activate alarm and stop pump.
- Must activate venous line clamp capable of complete occlusion of blood return line to 800mmHg (high compliance dialyzers will ‘‘squeeze’’ blood into the blood circuit even with the pump stopped).
- _Should not be oversensitive (to prevent unnecessary

alarms). [13]

II.8. Hemodialysis Generators

Figure II.6. The hemodialysis apparatus

The hemodialysis generators are machines that enable dialysis session. These are complex and expensive devices (more than one hundred thousand euros) which simultaneously ensure:

- production of dialysate and its adjustment to the prescription
- the circulation of dialysate through the
- dialyzer
- blood circulation in the extracorporeal circuit
- maintaining the whole circuit to the body temperature of the patient continuous monitoring of the composition of the dialysate
- the amount of liquid to the patient to be withdrawn

At these "basic" functions now, add optional modules also allow continuous measurement of various parameters to ensure the quality of dialysis. [13]

II.8.1 Gambro

Gambro is a laboratory of global medical technology leader in the development, manufacturing and supplying products and therapies for Kidney and Liver dialysis, the treatment of renal failure due to myeloma and other extracorporeal therapies reserved for patients with acute and chronic diseases.

Figure II.7.gambro machine

Renal dialysis is the first extracorporeal therapy (A therapy that treats the organ dysfunction outside the body) in the world. Each year dialysis saves a growing number of patients, and innovation in this area plays a key role. Currently, the only alternative to kidney dialysis, namely renal transplantation is not a viable option for most patients because of the shortage of donated organs. The technology of dialysis is now adapted to new applications, such as liver dialysis and other extracorporeal therapies booming to eliminate various liquids and toxins in patients with acute and chronic diseases. [18]

Specifications:

- MODEL : AK200 ULTRA S
- BLOOD CIRCUIT
  - ✓ Arterial pressure, mm hg (BLOOD CIRCUIT) :-700 to +750
  - ✓ Venous pressure, mm hg (BLOOD CIRCUIT) :-700 to +750
  - ✓ Blood pump range, ml/min (BLOOD CIRCUIT) :0-500
  - ✓ Heparin pump range, ml/hr (BLOOD CIRCUIT) :0-10
- Dimensions (hxwxd) cm (in) (GENERATOR) :130 x 57 x 75 (51.2 x 22.4 x 29.5)
- WEIGHT, kg (lb) (DISPLAY) : 80-87 (176.4-191.8) 4
- DIALYSATE DELIVERY: AK200 is 77-86 kg (170.1-189.6 lb).
- Comfort control, Â°c (DIALYSATE DELIVERY) : 30-40

- Temperature alerts c (DIALYSATE DELIVERY): 28-41.

Figure II.8.Hemodialysis blood line

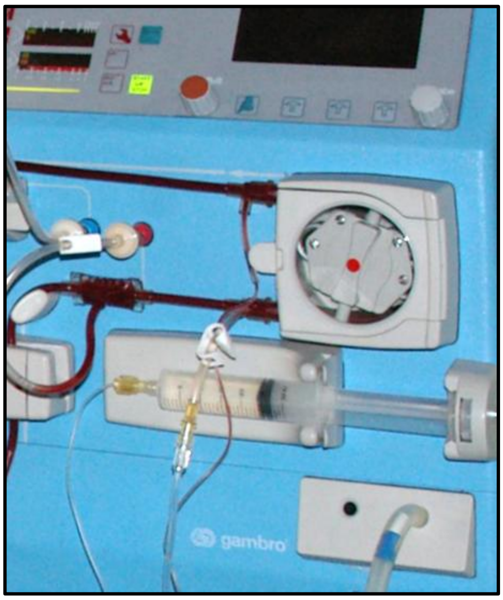

Figure II.9. Pump blood

II.8.2 Machine Classic - Hemodialysis

Fresenius Medical Care works to constantly improve new treatments and dialysis products in order to improve clinical outcomes for dialysis patients. While focusing on the implementation scope of the most advanced modality of hemodialysis, hemodiafiltration (HDF) "online" or online, we also recognize our responsibility to provide quality treatment for those, which cannot prescribe. [19]

Specifications:

- Dimensions 1370 x 480 x 480 mm (HxWxD) (Depth of base: 630 mm)
- Weight: about 86 kg
- Inlet pressure water from 1.5 to 6.0 bars
- Inlet temperature of the water of 5 ° C to 30 ° C
- Maximum height of 1 m drain
- High pressure suction power 1 m
- Power supply: 230V ± 10%, 47-63 Hz

Options:

• BPM: Blood Pressure Monitor

The monitor is a monitor BPM non-invasive blood pressure, fully automatic, operating on oscillometric principle.

It is possible to perform measurements at preselected intervals:

• Interval Mode: 5-15-30-60 Minutes

• Fast mode for measurements every 30 seconds a.

The following parameters are recorded and displayed in graphical form:

• systolic blood pressure

• diastolic blood pressure

• Mean arterial pressure (MAP)

Alarm limits for each parameter can be adjusted taking into account the specific conditions related to each patient.

• Double pumps

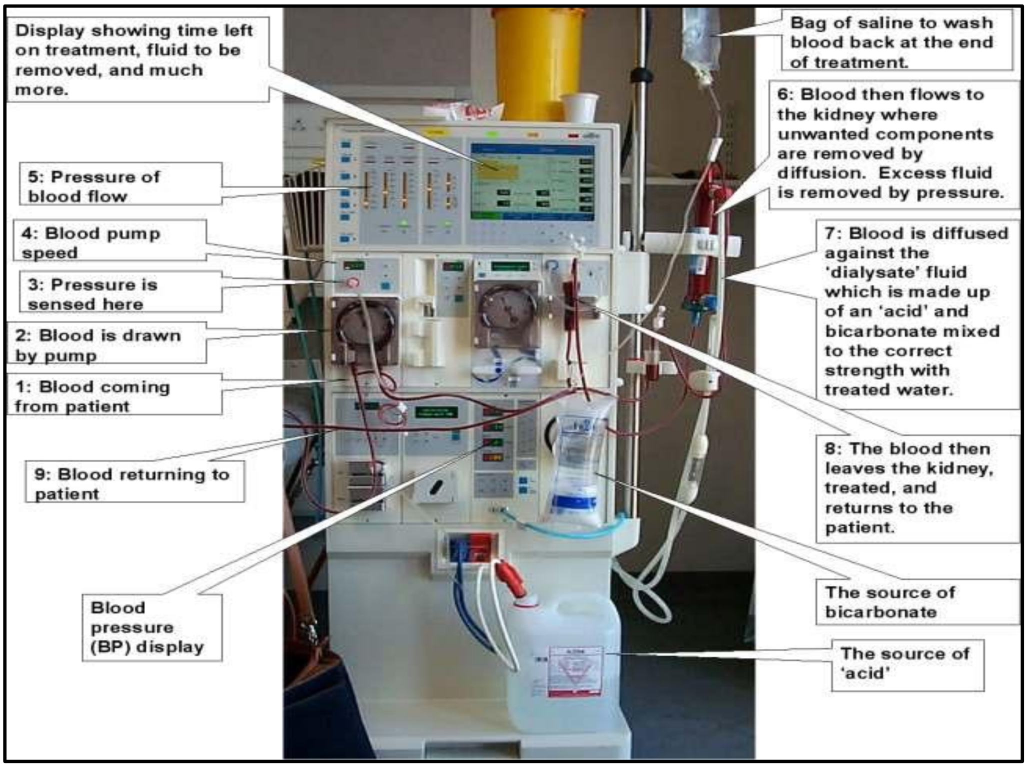

Figure II.10. Fresenius machine

II.8.3 Générateur « Dialog+ » avec Tensiomètre Intégré

Figure II.11. Generator Dialog+

Benefits:

Generator can measure dialog- dialysis –: before, during and after the session. Automatic measuring cyclic screen display pressure and heart rate setting manual or automatic display different colors alarms, pressure and frequency measurements stored in real time automatic adjustment of the inflation pressure of the cuff accurate monitoring and safe voltage.

Specification:

Measuring range of 60 to 245 mmHg systolic pressure 40-220 mmHg diastolic 40-235 mmHg MAP accuracy + / - 3 mmHg or + / - 2% - Automatic alarm setting - limits to + / - mmHg last measured value - in critical mode + / - 10 mmHg last measured value - measurement time : (adult with a pressure of 120 mmHg and pulse 80/min) 28 seconds - 0-320 mmHg cuff pressure - pressure default 200 mmHg - pressure targeted last SYS + 30 mmHg - 300 mmHg overpressure safety + / - 10% - frequency measuring 40-200 / min - accuracy + / - 2% or 2/min - armbands available in three sizes.

General Characteristics:

voltage: 230 V Frequency: 50/60 Hz current: max.10 A

- Dimensions (WxDxH): 555 x 625 x 1450 mm
- Weight: 101 kg
- Water supply pressure : 0.5 to 6 bar
- Temperature: 5-30 ° C
- Concentrate feed : cans or centralized bicarbonate cartridge pressure : 0-1 bar
- Standards : EN 60601-1 (IEC 60161) EN 606901-2-16 (IEC 601-2-16) EN 55011 EN 60601-1-2 (IEC 601-1-2) - EN 60529 (IP 21) Complies with Directive MDD 93/42/EEC. [20]

II.9. Conclusion

This chapter is an introductory part to understand better the dialysis machine, its components, its environment and the different functions it can perform, in addition to its importance in the lives of these special patients. Therefore, this chapter is intended to provide general and necessary knowledge about this machine, the subject of our study. [21]

Chapter 3

Simulation Results

III.1. Introduction

The application we chose (the generator Gambro AK -10) is a former model consists of several systems of different types. There are the electrical, electronic, hydraulic, and mechanical systems. What is missing in this application are the mathematical models of these systems. To better manage our study, we found ourselves obliged to generate our own models. This is why this chapter is found.

Before starting the development of the parameter, a prior summary description of our machine is given. It has already been mentioned in chapters (II) that the generator is composed of three main modules: blood (BMM: Blood Monitor), the fluid module (DFM: Fluid Monitor) and ultrafiltration module (FCM Filtration Control Monitor). In each module, there is a control stage (printed circuit board) which controls the hydraulic circuits (valves, pump motors).

We used in this simulation Matlab (R2013), my pc TOSHIBA processor Intel CORE 2 DUO T6670 2.20 GHZ, and the RAM 2GO and graphic card : mobile intel(R) 4 series 1GO.

In our work, I will focus on blood unit (BMM: Blood Monitor), and improvement.

III.2. Consider of test function

We use simulation technology Matlab for simulation algorithm bees, with test function for guarantee us true program that can be used in our study on the control and improvement of blood pressure in a hemodialysis.

III.3. Practical part

In this part we test our Bees colony algorithm with several functions to ensure that out algorithm work perfectly and with acceptable results and the deferent test are presented in the next section.

III.3.1 First function $f(x) = 15 * x - x^2$:

For this function, we calculate maximum value with Matlab and we have acquired these results:

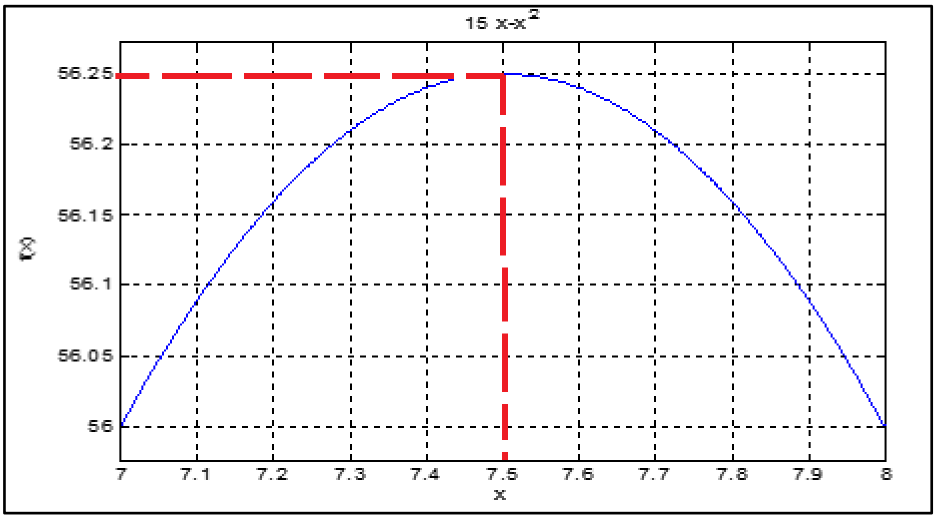

Figure III. 1. Plot Max of Function$f(x) = 15 * x - x^2$

Theoretically, we know the maximum value of this function that is in the interval [7 8]. In the program which we have done, we found that there is only one solution for the job and the value x_Best=7.5 and f_Best(x) =56.25 represents the highest value, as shown in figure III.1.

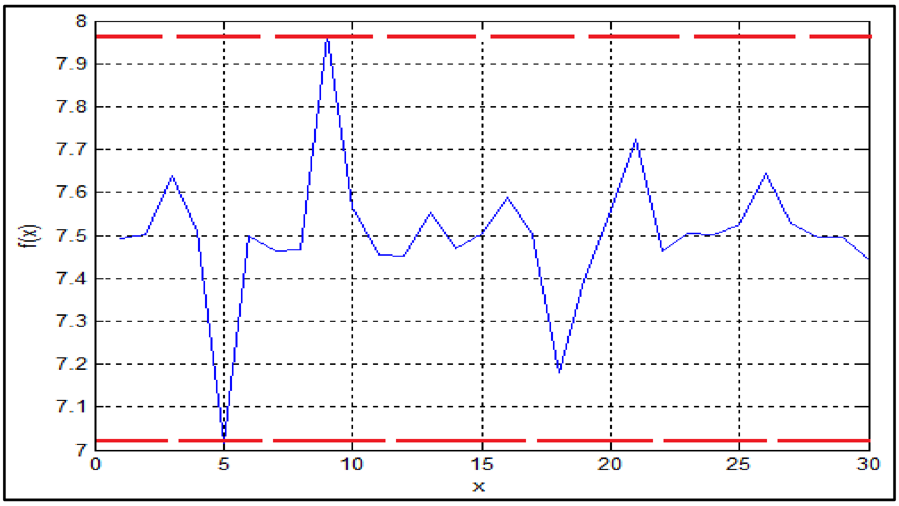

Figure III. 2. Variation of the best solution for 30 runtimes

Figure III.2 notes that in each iteration, it takes the best values and puts it in vector and repeats the same process in each iteration. At the end, we take the best values of this vector.

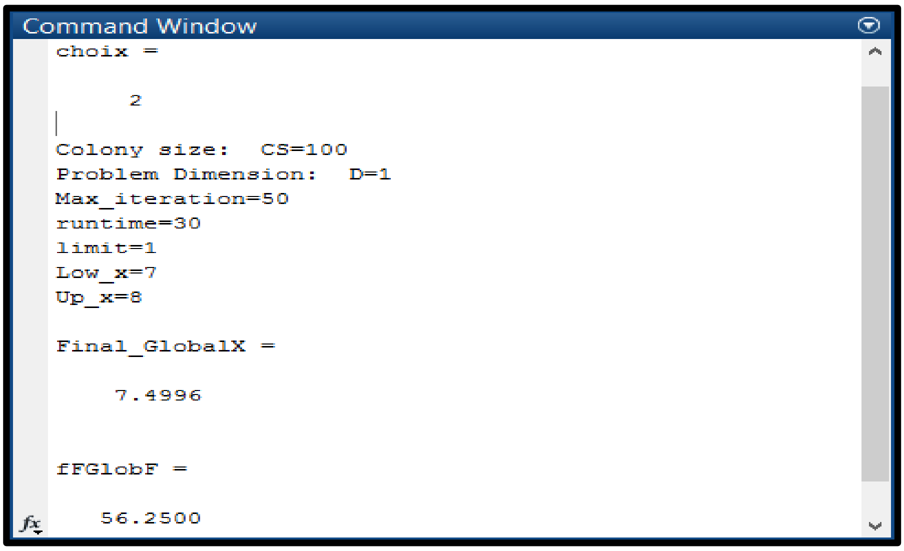

Figure III.3. Result of the Calculation $x_{best} et f_{best}$ for $f(x) = 15 * x - x^2$

III.3.2 Rastrigin function

III.3.2.1. *Definition*

Rastrigin's function is based on equation III.2 , with the addition of cosine modulation to produce many local minima. Thus, the test function is highly multimodal. However, the location of the minima is regularly distributed.

Function definition:

$f(x) = 10.n + \sum_{i=1}^{n}(x_i^2 - 10.\cos(2.\pi.x_i))$ -5.12<=xi>=5.12 (III.1)

$f(x)=10\cdot n+sum(x(i)^{2}-10\cdot \cos(2\cdot pi\cdot x(i))), i=1:n; -5.12<=x(i)<=5.12.$ (III.2)

global minimum :

$f(x)=0 ; x(i)=0, i=1:n.$ (III.3)

Fig. III.4. Visualization of Rastrigin's function; left: surf plot in an area from –5 to 5, right: focus around the area of the global optimum at [0, 0] in an area from –1 to 1. [22]

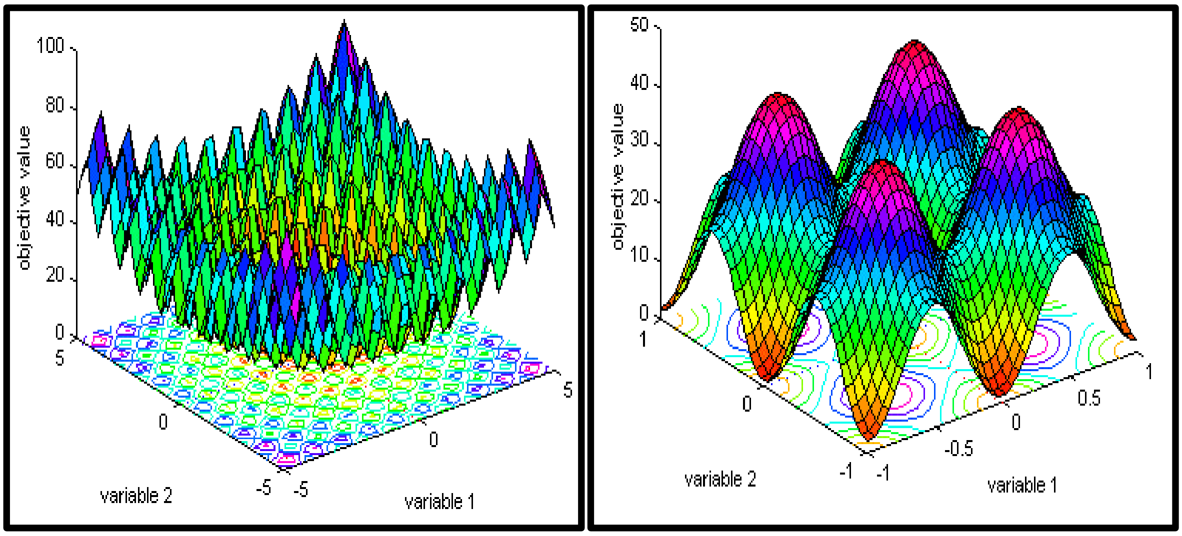

Figure III.4.Rastrigin Function

III.3.2.2. Practical Part for Rastrigin

To evaluate my program ‘algorithm bee’, I used function Rastrigin that calculates the minimum value. This is shown in Fig III. 5.

As the plot shows, Rastrigin's function has two local minimum. However, the function has just one global minimum, which occurs at the point [0 0] in the x-y plane, as indicated by the vertical line in the plot, where the value of the function is 0. At two local minimum other than [0 0], the value of Rastrigin's function is greater than 0. The farther the local minimum is from the origin, the larger the value of the function is at that point. And in Fig III.6, In each execution, we have much iteration after we randomly select x_best and put them in a new vector and plot in this vector. We found that it work in the interval between [-1, 1].

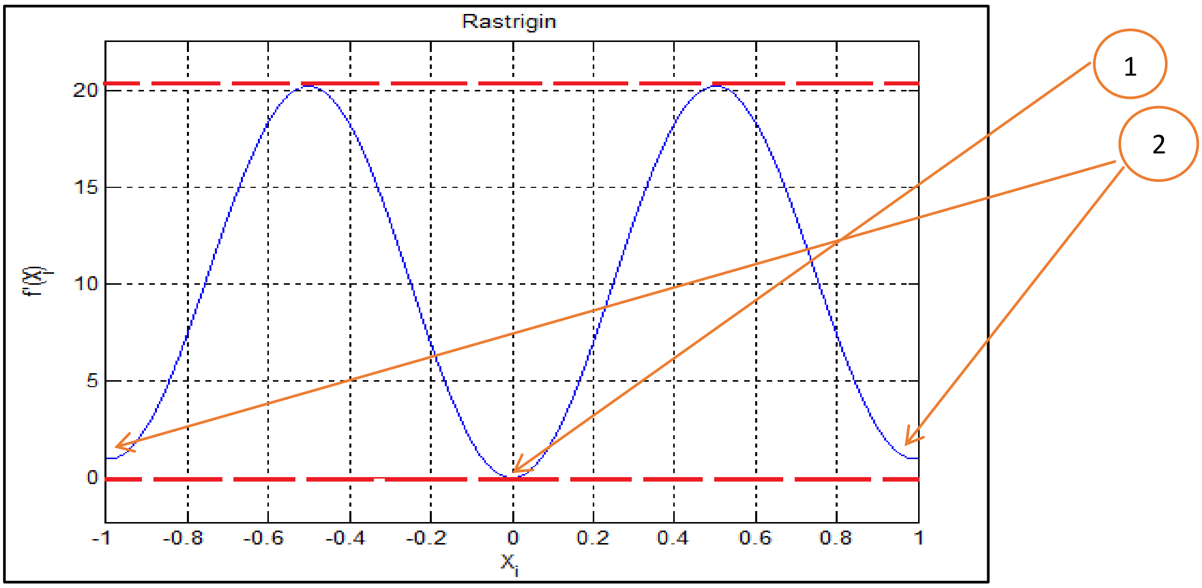

Figure III. 5. Plot Function Rastrigin

1 : Global minimum

2 : Local minimum

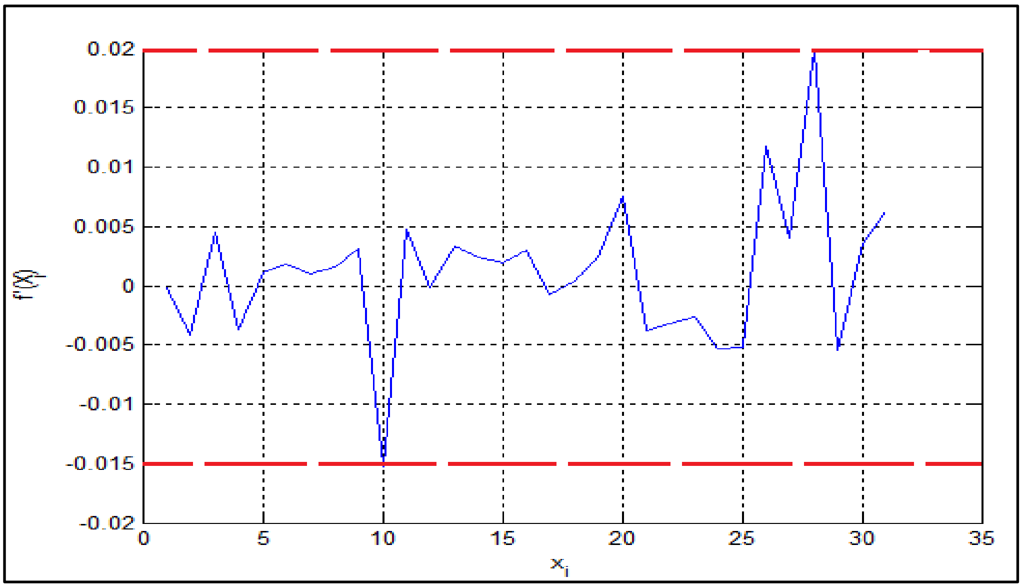

Figure III.6. Variation of the best solution for 35 runtimes

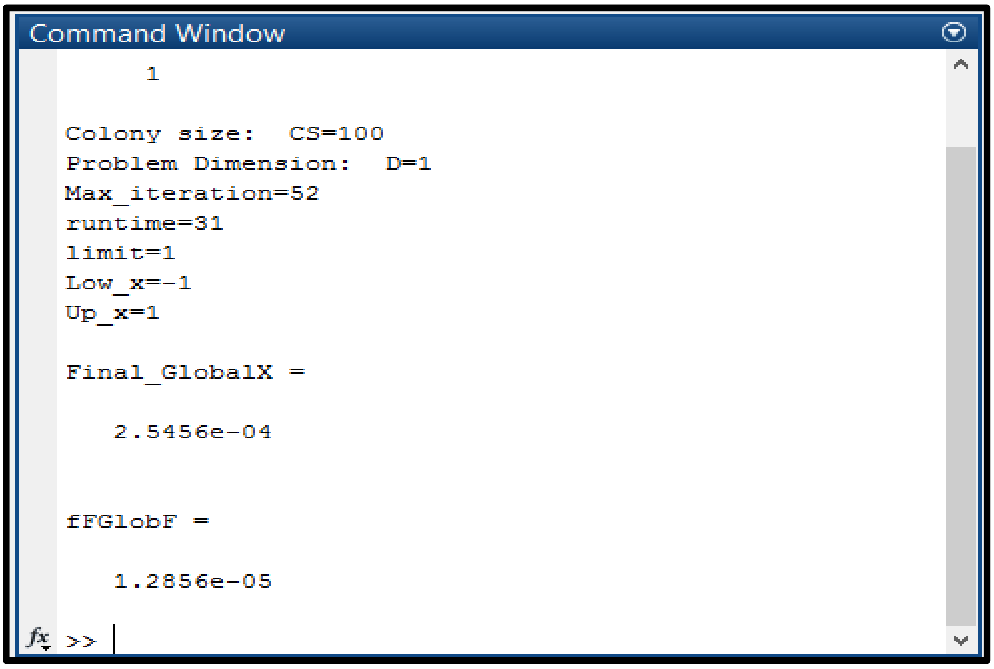

Figure III.7. Result of the Calculation $x_{best}etf_{best}$for Rastrigin

III.3.3 Another function is applied $f = x(1)^2 + x(2)^2$,

We found these results:

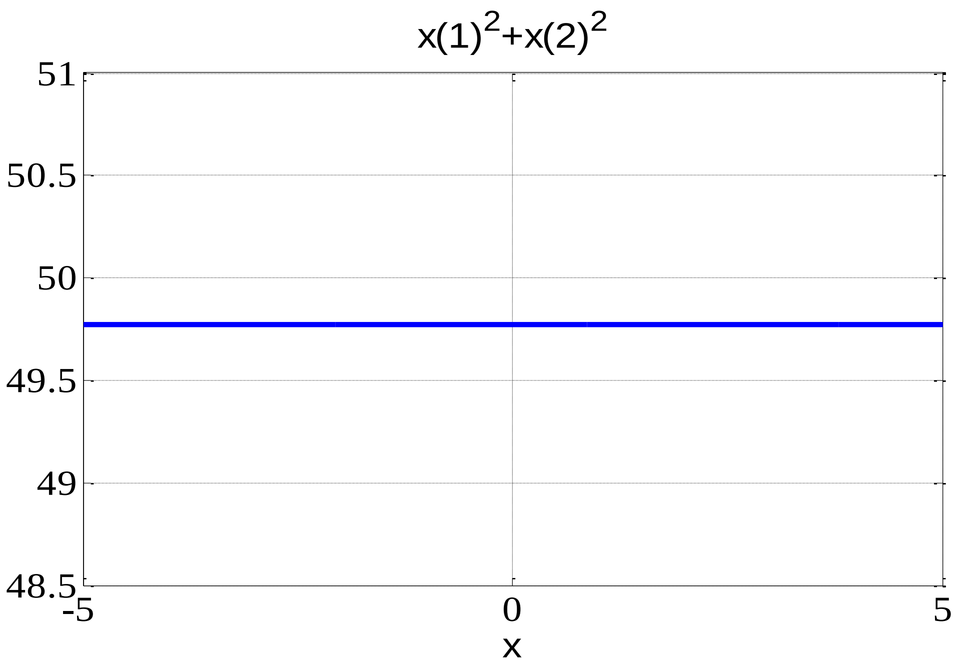

Figure III.8.Plot Function $f = x(1)^2 + x(2)^2$

This function is limited by the interval [-5, 5]

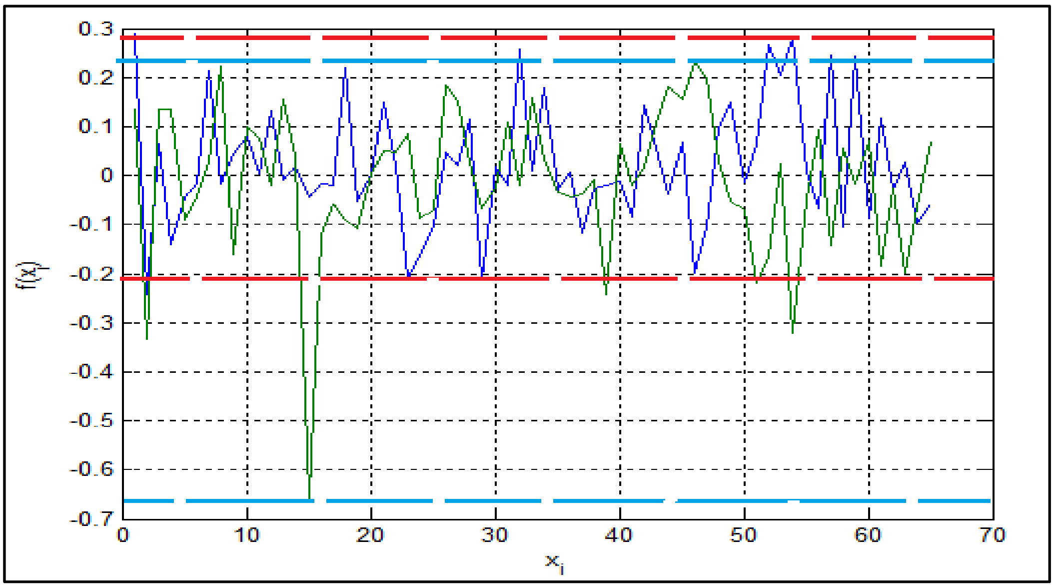

Figure III. 8.Variation of the best solution for 70 runtimes

In each execution, we have much iteration after we randomly select x_best and put them in a new vector and plot in this vector. We found that it work in the interval between [0, 70].

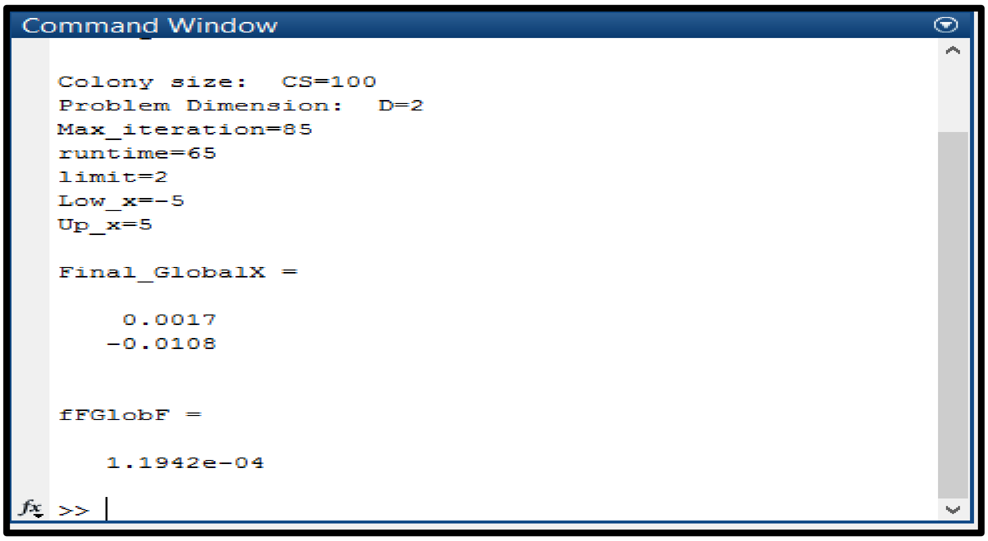

Figure III.10. Result of the calculation $x_{best} et f_{best}$ for Rastrigin

This figure present the the simulation results of x_{best} $et f_{best}$ for Rastrigin under matlab

III.4. Pressure:

Simplified closed circuit control block diagram is summarized as follows fig.III.11.

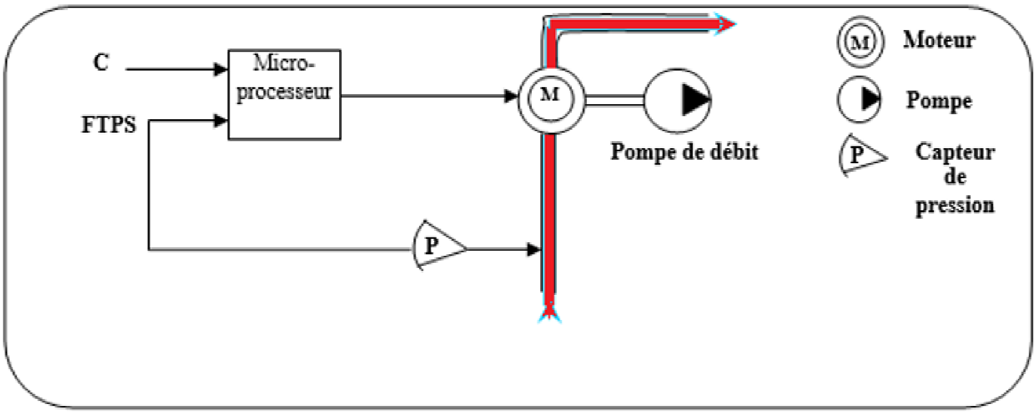

Figure.III.11.Simple Diagram of the Pressure Control Loop

Always C = PSEV: +100 /-400mmHg: is the specific reference to the application, generated by an external potentiometer and sent to the microprocessor calculates.

NPTS: signal representing the sensed pressure value, which in turns be sent to the microprocessor for comparison with the set point.

The microprocessor calculates, and then generates the motor control signal to the pump suction. Thus it regulates the pressure setting.[22]

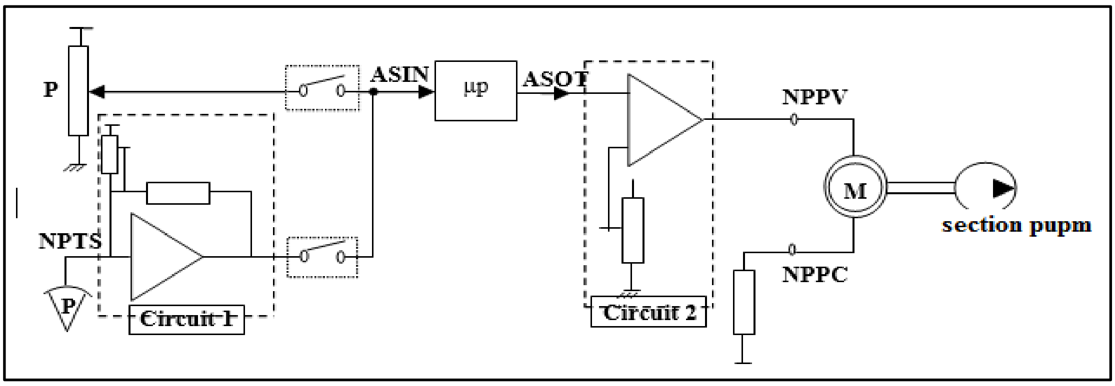

Figure III.12. Simplified Electrical Circuit Pressure

Circuit 1: This is a summer with:

$V_{e1} = E = 10V$, $V_{e2} = 10 \cdot K$ ($K = \overline{0.1}$), $V_{e3} = NPTS$

R_1=75 KΩ, R_2=1MΩ, R_3=22.1 KΩ, R_4= 221 KΩ, is obtained:

Circuit 2: 2 is the same circuit used in the flow control, and:

$$NPPV = \frac{2(1+0.142p)}{(1+0.87p)(1+10^{-5}p)} \cdot ASOT \qquad \text{(III.4)}$$

For NPPC it follows the same procedure as the previous circuit, and obtained:

$$NPPC = \frac{1.2 \cdot 10^{-3}}{(1+0.87p)(1+10^{-5}p)} \cdot ASOT \qquad \text{(III.5)}$$

III.5. Improved Pressure

To amelioration and control the blood pressure, we propose the system representing in fig III.13, the system contains pressure system, linear regulator and optimization algorithm to obtain the parameters of regulator.

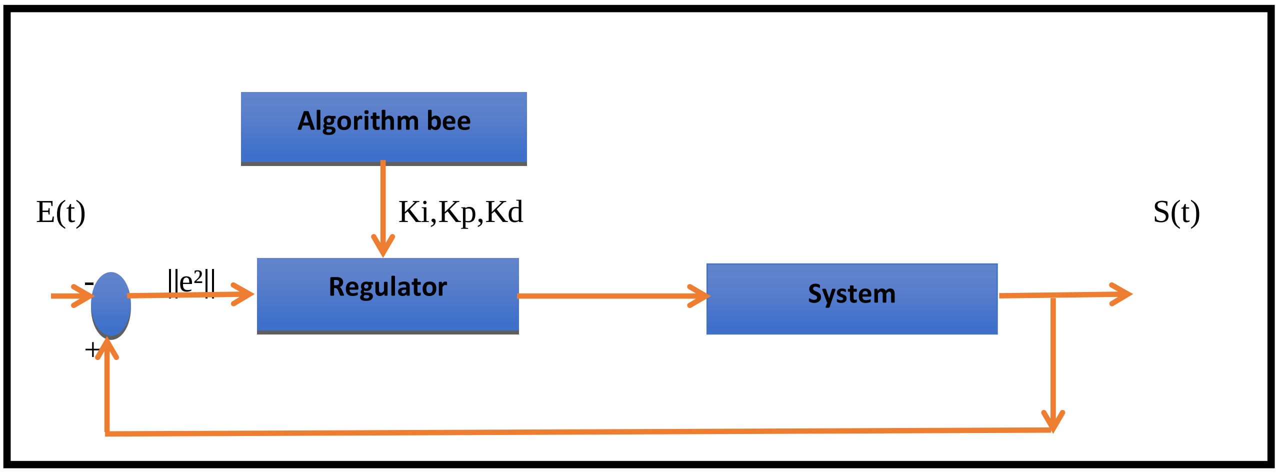

Figure III.13. Amelioration the System Pressure

III.5.1 Open loop

To show the behaviour of our system, we plot the open loop response of the system (figIII.15), and figure III.14 represent the Matlab Simulink model of the open loop system:

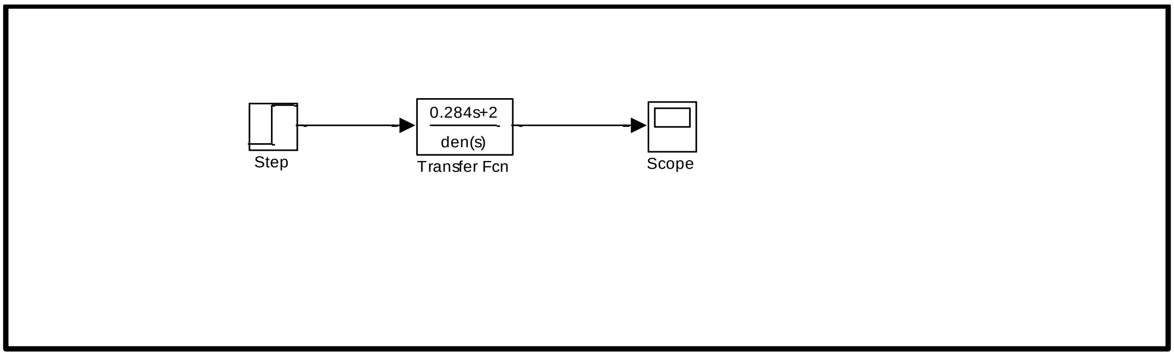

Figure III.14.Open Loop Simulink Model

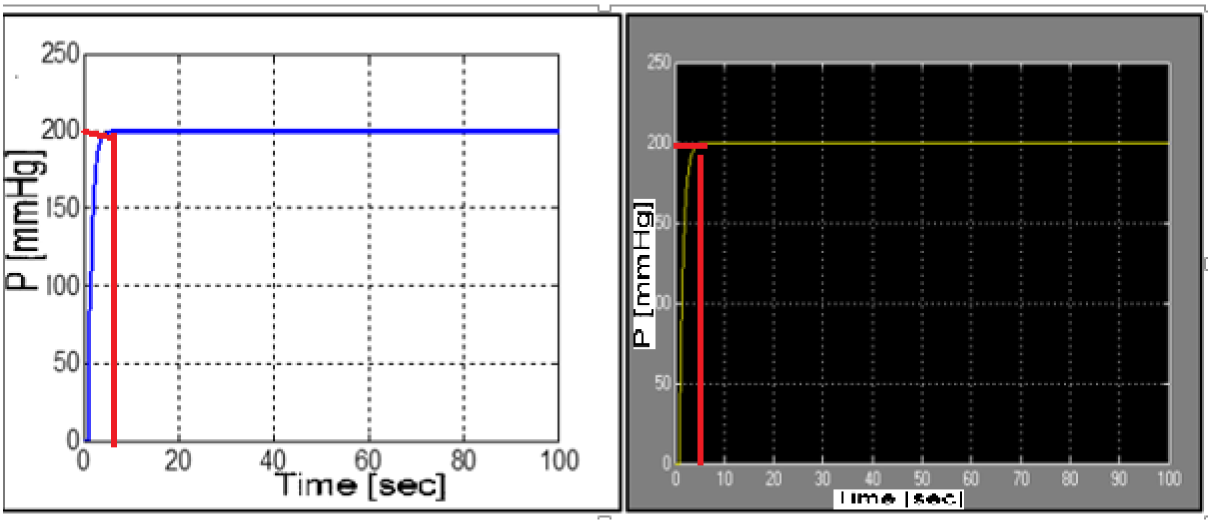

Figure III.15. Response Open Circuit

We note that there is a delay in response, and then we prove the value that system is 200mmhg, so this system is not controlling because it amplified the signal.

III.5.2 Closed loop

The simulation results and Simulink model of the closed loop of our system are represented in fig.III.17 and fig.III.16 respectively.

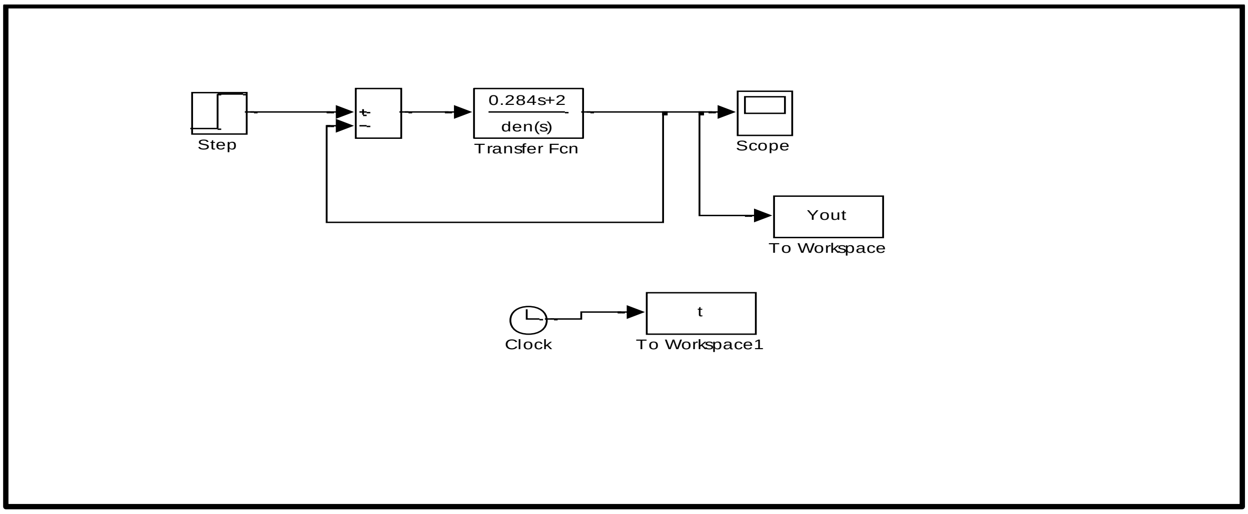

Figure III.16. Simulink Model with Closed Loop

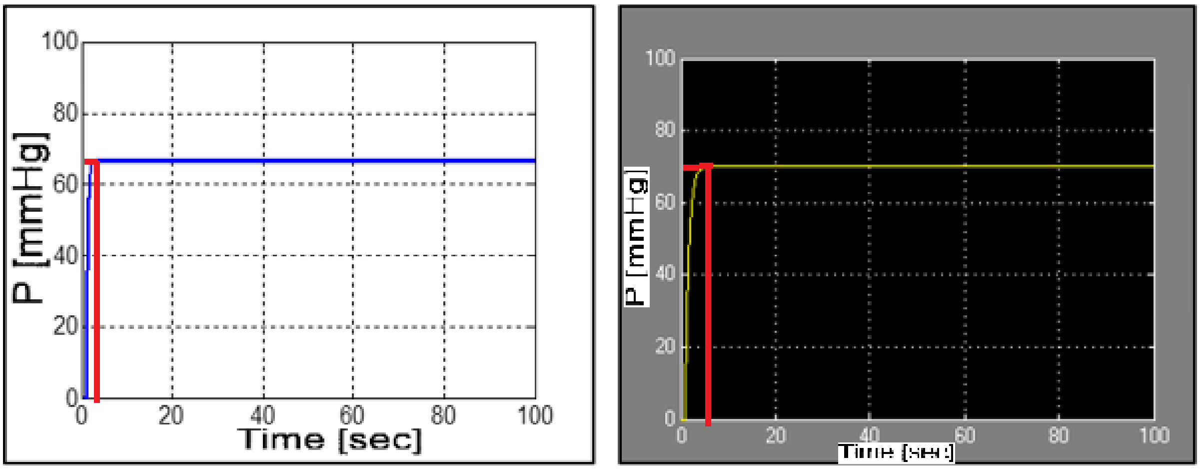

Figure III.17. Response Closed Circuit

This system connects the steady value 67mmhg after smaller retard.

From this curve, one can see that the output pressure does not follow our reference; so, we need a controller to regulate the output pressure.

III.5.3 Circuit with PID Propose

To control the output pressure, initially a linear PID controller is used. Figure III.18 and figure III.19 represent Simulink model and simulation response of our system using PID controller after some calculation parameters of the PID regulator are kp=0.2, ki=5 and kd=0.002 .

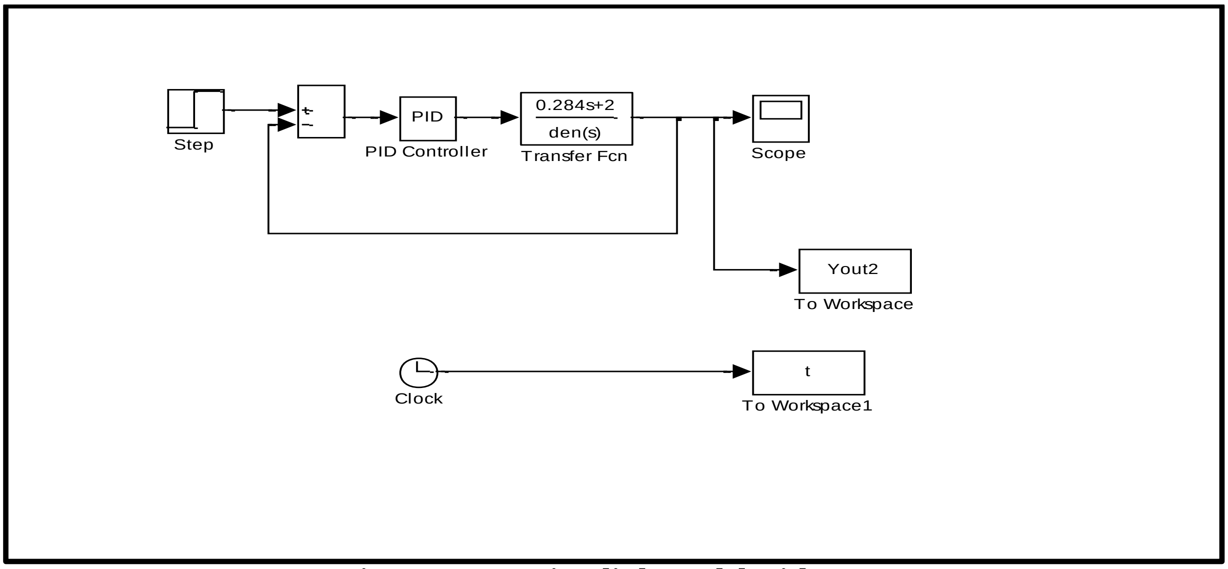

Figure.III.18. Simulink model with PID

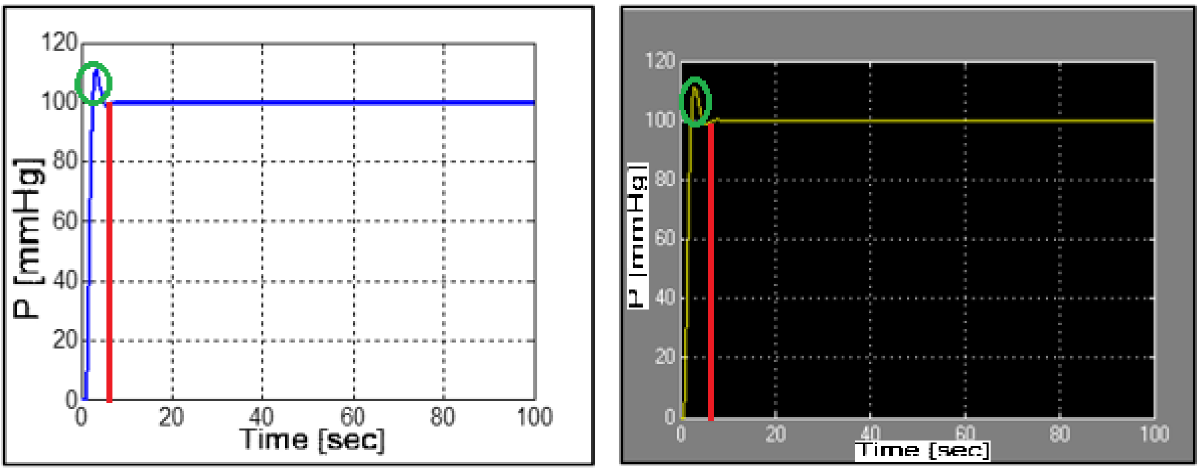

Figure III.19. Response with a Proposed PID

The simulation result shows the steady state response of the PID controller. It can be observed that the PID controller show low performance from overshoot equal to 10. To avoid such a situation and to resolve the important overshoot we propose ABC-PID controller based on the Bees colony algorithm to optimize the parameters of the PID regulator.

III.5.4 ABC-PID Controller

To ensure high performance and robustness of our system, a Bees colony algorithm with PID controller is proposed to control the blood pressure. The ABC algorithm allows us obtaining the Ki, KD and KP parameters of the PID regulator.

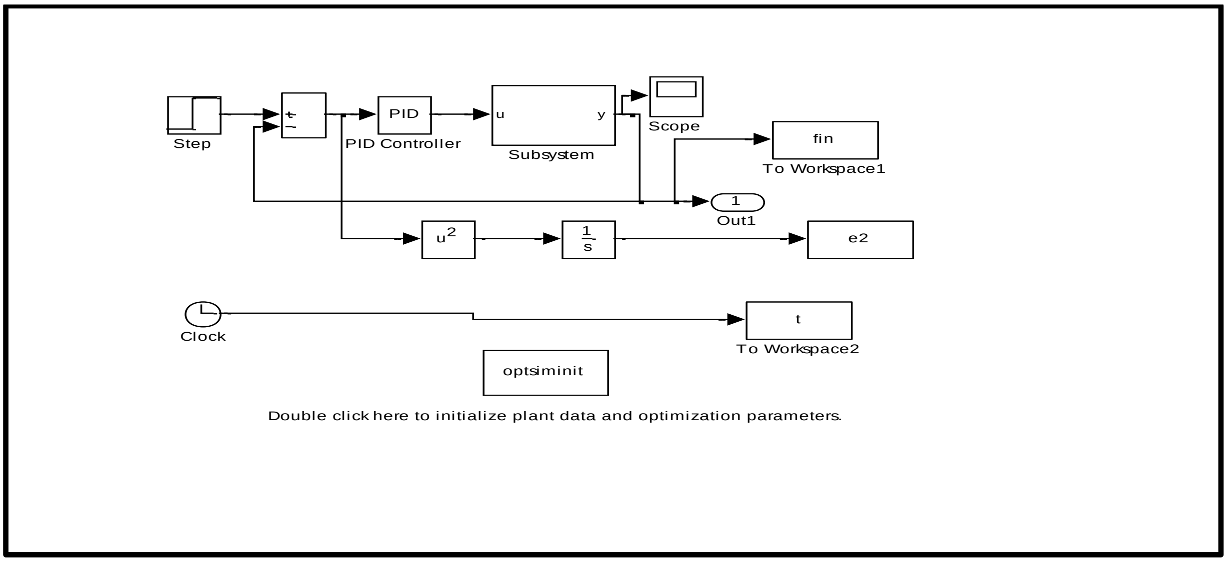

Figure III.20.Simulink Model with ABC-PID

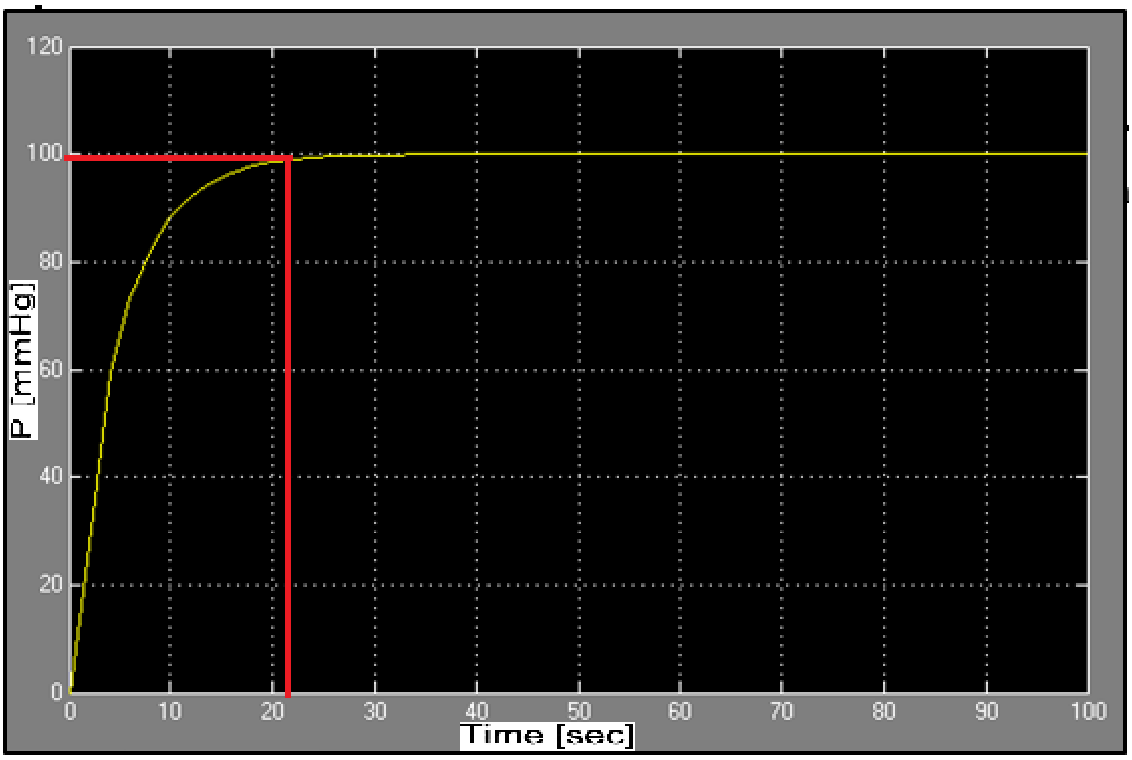

Figure III.21.Response with Proposed ABC-PID

After simulation with Matlab the Bees colony algorithm provides the parameters of the PID regulator as follows: kp=10, ki=11 and kd=1. With swarm size=100 ; runtimes=50 and itération=25 .

Figure III.21 represent the response of our system with the ABC-PID proposed controller, the pressure reference is fixed to 100. From this curve it is possible to observe that the system response follow our reference (pressure =100) perfectly with zero oscillations, overshoot and acceptable settling time comparing with figure III.19.

According the previous simulation result , we note that the proposed ABC-PID controller provide high performance like overshoot and settling time comparing with only PID controller .This proves the robustness of our proposed controller and the high efficiency to control the blood pressure of hemodialysis machine .

III.6. Conclusion

In this chapter, a Bees colony algorithm with PID controller was proposed to control the blood pressure. The proposed controller contain Bees algorithm to define the parameters of the regulator and linear PID regulator to control the pressure presents a high performance comparing by PID regulator only. The simulation results prove the performance of the proposed controller.

General Conclusion

The aim of this thesis was to propose regulator based on Bees colony algorithm to control the blood pressure of hemodialysis machine. The artificial bee colony algorithm (ABC) is an optimization algorithm based on the intelligent foraging behaviour of honey bee swarm, proposed by Karaboga in 2005. It is as simple as particle swarm optimization (PSO) and differential evolution (DE), but only uses two common control parameters namely colony size and maximum cycle number. The ABC system combines both local and global search methods in an attempt to balance exploration and exploitation processes, and hopefully, it can be successfully applied to solve real-world problems, the efficiency of the ABC algorithm is tested in our thesis by several functions of test.

In this case study, we use ABC algorithm to control the blood pressure with the following step, First we introduce the used algorithm and his application and presentation of the different hemodialysis machine, after we present failure kidney and operating principle, in the last chapter we present the different simulation result of our system with the proposed Controller.

The basic idea of the proposed controller is to use the Bees colony algorithm to optimize the parameters of the linear PID regulator according pressure variation. Comparing with linear PID regulator, the proposed controller assure high performance and high robusstness with pressure variation .The simulation results show that the blood pressure follow thier reference perfectly with negligible overshoot and fast response that prove the efficiency of the ABC-PID controller..

As future prospects of this work we propose:

- The use of another method of optimization like PSO or genetic algorithm and compare with Bees colony algorithm.
- The use of another non linear regulator like fuzzy logic or neural network.

Bibliography

[1]: Horst F. Wedde, Muddassar Farooq and Yue Zhang, Informatik III, University of Dortmund ,44221, Dortmund, Germany{wedde,farooq,zhang}@ls3.cs.uni-dortmund.

[2]: Pham DT, Ghanbarzadeh A, Koc E, Otri S, Rahim S and Zaidi M. The Bees Algorithm. Technical Note, Manufacturing Engineering Centre, CardiffUniversity, UK, 2005.
[3] :Karaboga.D, (2005). An idea based on honey bee swarm for numerical optimization. Technical Report TR06, Erciyes University, Engineering Faculty,Computer Engineering Department, 2005.2006
[4] : Bee algorithm, jeudi 27 juin 2013, 23 :14:00, pdb.

[5]: Adil Baykasoùlu1, Lale Özbakır2and Pınar Tapkan²,1University of Gaziantep, Department of Industrial Engineering 2Erciyes University, Department of Industrial Engineering Turkey

[6]: Artificial Bee Colony Algorithm, lundi 7 avril 2014, 20:17:54

[7]: Malek Alzaqebah and Salwani Abdullah International Journal of Soft Computing and Engineering (IJSCE), ISSN: 2231-2307, Volume-1, Issue-5, November 2011

ISSN: 2231-2307, Volume-1, Issue-5, November 2011

[8]: Rung-Ching Chen , Wei-Lung Chang, Chia-Fen Shieh and Cliff C. Zou 2012 Third International Conference on Innovations in Bio-Inspired Computing and Application ,pdf

[9]: optimization-par-colony-dabeilles-doc lundi 7 avril 2014, 20:17:56.pdf

[10] : University of Belgrade, Faculty of Transport and Traffic Engineering
TATJANA DAVIDOVI´C (Bee Colony Optimization : The Applications Survey)

[Organigramme]International Journal of Soft Computing and Engineering (IJSCE) ISSN : 2231-2307, Volume-1, Issue-5, November 2011

[11] : The basics of hemodialysis equipment, lundi 7 avril 2014, 20 :22:53

[12]:http://www.merckmanuals.com/home/kidney_and_urinary_tract_disorders/biology_of_the_kidneys_and_urinary_tract/kidneys.html?qt=kidneys&alt=sh

[13]: https://www.boundless.com/physiology/definition/kidney/

[14]: http://www.medicalnewstoday.com/articles/172179.php

[15]:http://www.utc.fr/~farges/dess_tbh/01_02/Projets/autodial/autodial.htm#II%201%20%CB%86%20D%C3%A9finition%20et

[16]: http://gil1.home.pipeline.com/esrd/

[17]:http://fr.questmachine.org/wiki/La_dialyse_r%C3%A9nale

[18]:http://fr.medwow.com/med/hemodialysis-machine/gambro/ak200-ultra-s/3381.model-spec

[19]:http://www.fmcmaroc.com/cps/rde/xchg/SID-19317DD9-EBDF6547/fme-ag_ma/hs.xsl/2341.htm

[20]:http://www.cadesmedical.fr/products/hardware/generateur-dialog-avec-tensiometre-integre_261.html

[21]:,modélisatio lundi 12mai 2014, 11:21:00

[22]: Examples of Objective Functions, vendredi 16 mai 2014, 00:06:17