

# FUNCTIONAL ANALYSIS AND SUPERVISION OF A WEIGHING SYSTEM OF A GRAIN SILO

M.N LAKHOUA<sup>1</sup>, A. BALTI<sup>2</sup>, R. TRIKI<sup>3</sup>

<sup>1</sup>Université de Tunis El Manar, Ecole Nationale d'Ingénieurs de Tunis, LR11ES20 ACS, Tunisie  
MohamedNajeh.Lakhoua@ieee.org

<sup>2</sup>Université de Tunis, Ecole Supérieure des Sciences et des Techniques de Tunis, SICISI unit, Tunisie.  
baltiala@yahoo.fr

<sup>3</sup>SMCSA-GC, Silo de stockage de céréales de Djebel Djloud, Tunisie

**Abstract:** After a presentation of the part of the automation and the supervision in the upgrading of the process systems, we present the issues involved in the application of a Functional Analysis (FA) technique on a supervisory system of a weighing system of cereals. Our contribution consists on applying a FA technique SADT (Structured Analysis Design Technique). This technique allows a functional description of the weighing system of cereals. The paper briefly discusses the functionality of the weighing system of cereals and some advantages of the application of the FA for the design of a supervisory system. Then the basic principles of the application of the supervision of the weighing system are presented. Finally, the different results obtained from the application of supervision are discussed.

**Key words:** Supervision; Functional analysis, Weighing; Grain silo.

## 1. Introduction

The automation and the supervision constitute nowadays essentially the key factors of the existence of several enterprises in the global setting of the upgrading in order to answer to requirements of their customers (strict load notebook, maximal production capacity, restraint perfect of the margin...) [1]. It is in this mind that, in the setting of a qualitative gait, the upgrading of the control - command system and the supervision of grain silos are important operations.

In fact, the automation represents an important gap in the command of new technical systems. This function has become much practiced either by the designers or by the operators of technical systems [2]. For this purpose, some older systems have also become an application domain of the automation. Indeed the problem of an automation project resides in how to respond in a clear manner the two essential following questions: What hardware to use for a given project automation? What are the scenarios that must ensure the project automation?

The integration of an automated and a supervisory system of cereal weighing is nowadays, very important, because of the advantages that it present in terms of clutter, and

exploitation suppleness. The supervision of the weighing system of cereals contributes to the improvement of the storage speed and by optimization in the time of the grain silos handling.

Functional analysis is a suitable approach used to explain the working of complex systems [3]. There are many synonyms for "functional analysis" such as: specification, functional specification, structured analysis, and functional description.

The basic idea of functional analysis is that the system is viewed as compound function. Functional analysis assumes that such processing can be explained by decomposing this compound function into a set of simpler functions that are computed by an organized system of sub-functions. The hope is that when this type of decomposition is performed, the sub-functions that are defined will be simpler than the original function, and as a result will be easier to explain [4].

In this work, we propose a functional analysis for the weighing system using SADT method (Structured Analysis Design Technique). SADT is a diagrammatic notation method designed specifically for describing systems as a hierarchy of functions and used in this investigation to describe the different functions and their relationships of the system [5].

In this context, the analysis of the weighing system of the grain silo of Djebel Djloud (near to Tunis) and the conception of an application of supervision is necessary in view to improve the existing system. This is why we present in this paper a practical case study of the grain silo of Djebel Djloud that is exploited by the SMCSA-GC (Société Mutuelle Centrale des Services Agricoles-Grandes Cultures) that plays an important role in general in the agricultural sector of the country and in particular in the cereal domain.

## 2. Presentation of the grain silo of djebel djloud

The grain silo of Djebel Djloud is exploited by the SMCSA since 1954 whose objective is to stock and to preserve quantities of cereals collected. Indeed, this grain

silo is the most important in Tunisia by its capacity of storage concerning the following products: hard wheat; soft wheat; barley; triticale.

The grain silo of Djebel Djloud includes notably an organized compact whole of 2 rows of section square cells, in reinforced concrete. The total number of cells is 20 cells. The total capacity of storage is about 650 000 quintals (65 000 tons) in wheat.

The silo of Djebel Djloud is composed of:

- 2 stations of receipt by wagon.
- 2 stations of receipt by truck.
- 3 stations of loading of truck.

The figure 1 presents the station of receipt of cereals in the grain silo of Djebel Djloud.



Fig.1. Stations of receipt of cereals

The tower of handling separates the two slices of the silo. This tower shelters notably equipments of vertical handling of cereals (elevators) and elements of the circuit (fans, fettlers, dispensers...).

This grain silo is composed of two whole of vertical storage unit, every whole of storage unit is called slice:

- The first slice is constituted of 8 cells and 12 bushels of loadings for a volume of total storage of 21000 tons.
- The second slice is organized of 12 cells for a volume of storage of 24000 tons.

Space on-cells shelter equipments of horizontal handling of cereals mainly, that are 8 transport strips of handling assuring the link between cells. Carriers of resumption to chain situated under waiting hoppers (TR1 to TR6)

- Carriers of resumption to chain situated in space under-cells (TR7 to TR11)
- Two elevators of resumption situated in the two hoppers of receipt (ER1, ER2)
- Four elevators situated in the tower of handling (E1, E2, E3, E4)

- Eight transport bands on-cells assure the link between cells (marked TB1 to TB8)

The weighbridge is constituted of an apron, in reinforced concrete, that rests on the electronic sensors. It permits to do operations of weighing to the entrance and the exit of cereal trucks. This system of weighing is ordered by a measuring of load and it is connected currently to a printer permitting the management of tickets (figure 2).

The weighbridge has the double type:

- Mechanical transfer of the weight.
- Electric transfer of information, visualization of the weight by digital reading with the possibility of impression and adapted on all computerized automatic device system.

The different stages of weighing by the weighbridge are:

- Weighing of the total truck.
- Stake in memory the gross weight.
- Stake in memory weight of the tare.
- Calculation of the net weight.

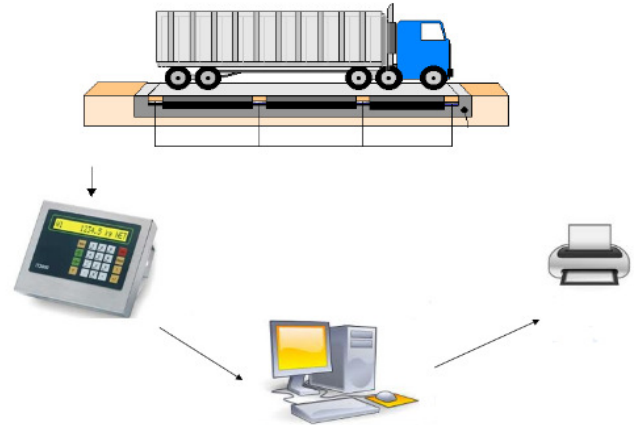


Fig.2. Interfacing of the weighbridge

The weighbridge includes 6 sensors type CB50X-DLS.

The CB50X-DLS is a numeric sensor of compression force which its features are the following:

- Sensor of weight achieved in rustproof steel tightly welded IP68,
- Protection anti-ovoltage in option,
- Capacities: 5, 10, 20, 30, 40, 60 tons,
- Sensitivity: 200 000 points
- A/D conversion: 24 bits, 100 mesures/sec.
- Numeric link: RS485 - 19600 bauds

The sensor of compression CB50X-DL presents a conception voluntarily simple in order to guarantee its long-term reliability. The weight to measure is thus directly applied on the sensor without making call to mobile mechanical elements.

### 3. Presentation of the SADT method

The SADT method [6] represents an attempt way to apply the concept of focus groups specifically to complex systems description, eliciting data from groups of stakeholders or organizational teams. SADT is characterized by the use of predetermined roles for group/team members and the use of graphically structured diagrams [7]. It enables capturing of proposed system's functions and data flows among the functions.

SADT, which was designed by Ross in the 1970s [8], was originally destined for software engineering but rapidly other areas of application were found, such as aeronautic, production management, etc. Although SADT does not need any specific supporting tools, several computer programs implementing SADT methodology have been developed. One of them is Design: IDEF, which implements IDEF0 method [9]. SADT: IDEF0 represents activity oriented modelling approach (Fig. 1).

IDEF0 representation of a physical system consists of an ordered set of boxes representing activities performed by the system. The activity may be a decision-making, information conversion, or material conversion activity. The inputs are those items which are transformed by the activity; the output is the result of the activity. The conditions and rules describing the manner in which the activity is performed are represented by control arrows. The mechanism represents resources (machines, computers, operators, etc.) used when performing the activity [10]. The boxes called ICOM's input-control-output-mechanisms are hierarchically decomposed. At the top of the hierarchy, the overall purpose of the system is shown, which is then decomposed into components-subactivities. The decomposition process continues until there is sufficient detail to serve the purpose of the model builder [11]. SADT: IDEF0 models ensure consistency of the overall modelled system at each level of the decomposition. Unfortunately, they are static, i.e. they exclusively represent system activities and their interrelationships, but they do not show directly logical and time dependencies between them. SADT defines an activation as the way a function operates when it is 'triggered' by the arrival of some of its controls and inputs to generate some of its outputs. Thus, for any particular activation, not all possible controls and inputs are used and not all possible outputs are produced. Activation rules are made up of a box number, a unique activation identifier, preconditions and postconditions.

For SADT diagrams or function boxes, two events are considered for representing the activation states of the activities. The first event represents the instant when the activity is triggered off, and the second event represents the ending instant [12-13].

SADT method has got the following main advantages [14]:

- Large field of applications such as automation, software developments, management systems and so on.
- Facility and universality of the basic concepts.
- Existence of a set of procedures, advises and guidelines.

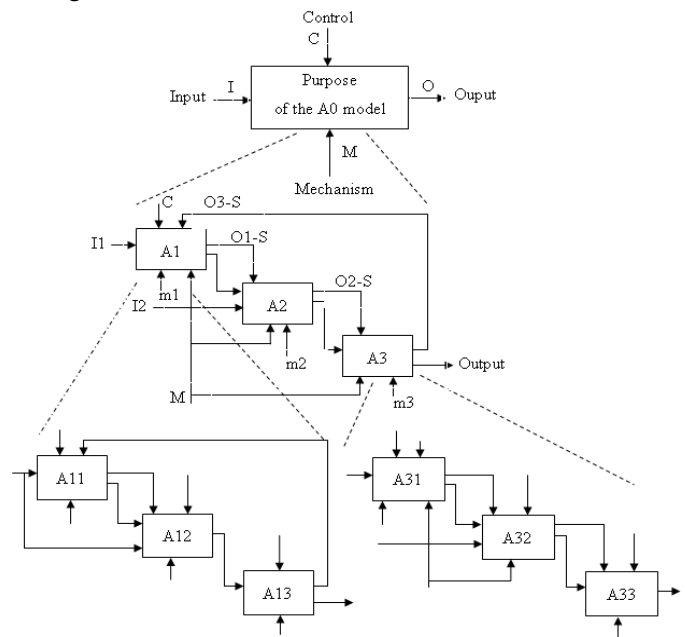


Fig.3. Top-down, modular and hierarchical decomposition of SADT

### 4. Functional analysis of the weighing system

Although the parameters of control and command of a storage device are varied (weight, temperature, humidity, clearing of gas, control of level, ventilation...), the weighing constitutes the central operation because it permits to control flow of entrance and exit. Thus, we limit to the survey of the weighing system. Considering the real environment of the grain silo to this effect, we examine its weighing system by the weighbridge [15-17].

In fact, the activity of weighing is a fundamental operation in the process of cereal storage. Indeed, to all operation of receipt or expedition of cereals, it is indispensable to weigh the incoming or retiring quantities of the grain silo.

In this part, we present a functional analysis of a weighing system of cereals. This analysis will constitute the strategy of modelling to achieve. This analysis will permit to specify borders of the system to not to pass on the one hand by the work of modelling and to specify data and the circulating information in the system and that will be used on the other hand by this modelling.

This is why we propose to study the existing weighing system in the grain silo of Djebel Djloud and we present the numeric environment of this system. This survey will exploit a functional analysis technique based on the SADT method.

The SADT model constructs is decomposed in a certain number of actigrams hierarchized into two levels (figure 4-5).

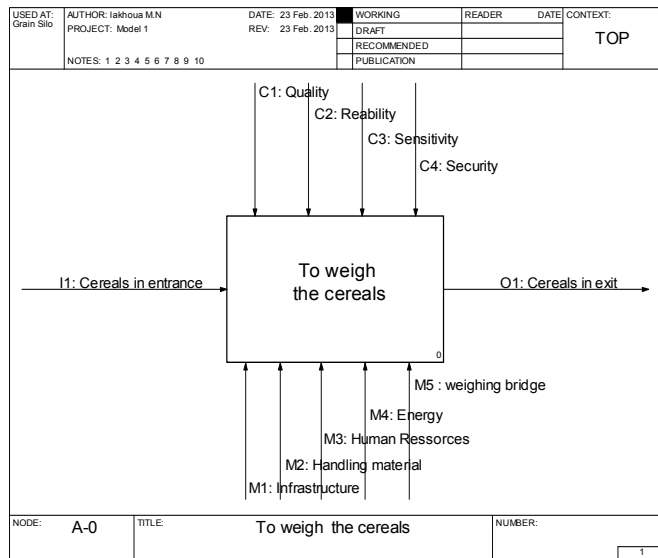


Fig.4. Node A-0 of the SADT model

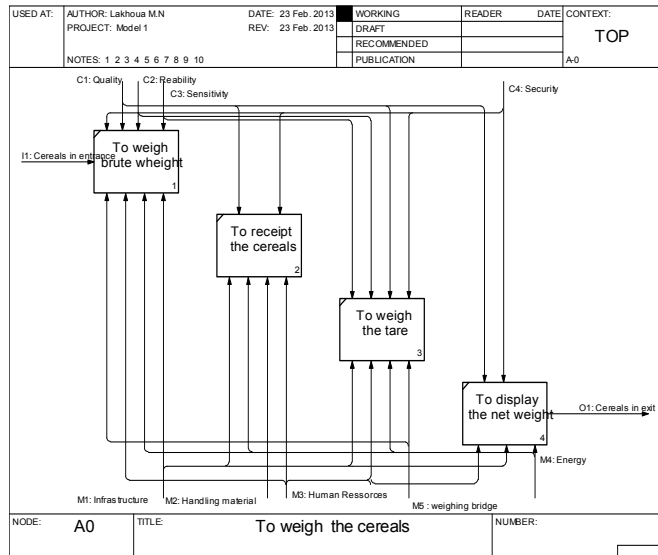


Fig.5. Node A0 of the SADT model

The table of hierarchization of nodes adopted at the time of the construction of the model describes stages of the incoming cereal weighing by truck.

After having presented the different elements of weighing system, we can distinguish insufficiencies of the control and supervision of this system that become indispensable

to reduce time and to accelerate the speed of handling operations at the time of the season of cereal mowing seen the increase of the frequency of truck succession for the storage or the expedition of the cereals.

The study of a weighing system in a grain silo consists of:

- a model of the weighing system,
- an application to adapt devices of measure, control and command to a numeric environment,
- an application of supervision of the weighing system.

Following the analysis done by the SADT method, it proves to be that the system requires an interfacing of control in order to improve the output and the efficiency of the weighing system and the handling of cereals. To this effect, we propose a prototype of supervision based on the permanent and automatic communication between sensors of weighing. This is why we choose the LabVIEW environment for the development of the application of supervision of the weighing system.

### 5. Supervision of the weighing system

Supervision systems permit to get the synthetic views of facilities or wholes of facilities in order to visualize their physical or functional states [18-19].

Situated in command rooms, supervision systems offer the possibility to centralize the vision and the physical organ piloting (sensors, auctioneers) sometimes very distant [20-25].

In this part, we present an application of supervision of the existing weighing system that interest to the control of the flow of propagation of products and the material of the transport (trucks).

Before writing the program of supervision, it is necessary to know the different stages of the control and their evolutions in the time. This description of the process is gotten by a temporal analysis of the behavior of the process to supervise.

The main role of studied system summarized by a working script that present the different operations to achieve. Every operation is spread out by an algorithm presented by an organization chart (figure 6).

The operation of the cereal weighing consists in receiving trucks on the weighbridge. The determination of truck state first of all compelled us to know the value of the weight detected by the weighbridge through the weighing sensor that sent a numeric signal of which a plot of data is reserved for the value of weighed, thereafter it is indispensable to verify the state of the weighbridge (absence or presence of truck). In case of presence of the truck the verification of its state takes place that one is

made by the tests on weights gotten at the time of the operation of weighing.

The operation direction of the truck consists in determining the direction of moving of the truck. Therefore the obligation of reading of the numeric signal sent the sensor of weighing and precisely the respective data plot to the determination of situation of the truck takes place after having verified that the weighbridge is charged.

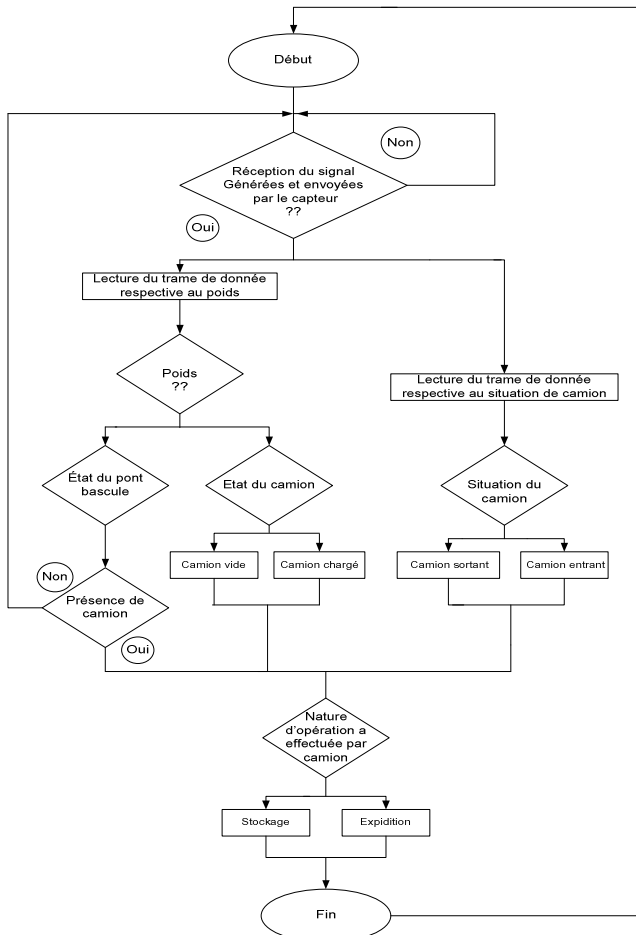


Fig.6. Main organization chart

The nature of the handling operation (storage or expedition) represents the action to make by the existing truck on the bridge topples. This last is done after having known the state and the direction of the truck.

The application of supervision of the weighing system of cereals is composed of three blocks. In, the first bloc, we have the part the LabVIEW software that permit us to construct a graphic interfacing capable to communicate with the sensor CB50X-DL of which receive data. Thereafter, the second block that represents the link between PC and the sensor has for role the adaptation of

signal. The third block designates the numeric data source generated by distortion of the sensor.

In this application of supervision, we used some structures of programming as case structure (figure 7).

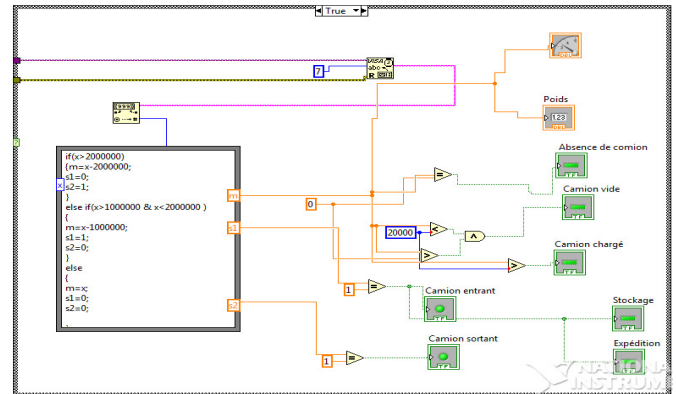


Fig.7. Example of the LabVIEW program

In order to assure the serial transmission in LabVIEW, we initialized the port RS485, by the fixing of the order wanted and parameters of the port, we configured the serial port as follows:

- port of communication : COM1,
- transmission speed : 19600 bauds,
- without bit of parity,
- one bit of stop,
- without control of flow.

If the distortion of the sensor takes place, a numeric signal is generated from where the signal will be transmitted by consequence the respective buttons to the nature of operation are light.

Figure 8 present a description of the graphic interfacing achieved by the LabVIEW software.

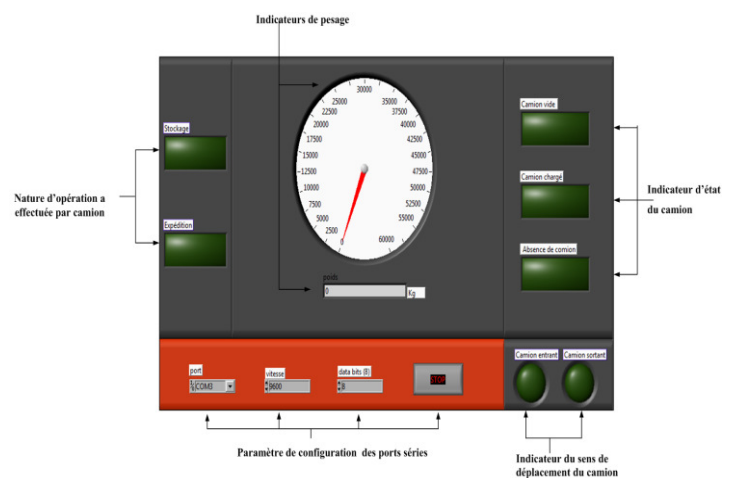


Fig.8. Description of the graphic interfacing

After having achieved the prototype of supervision, we tested this prototype through a simulation (figure 9-10) of the different scripts of handling (storage and expedition).



Fig.9. Visualization of handling data for different scripts of storage



Fig.10. Visualization of handling data for different scripts of expedition

## 6. Conclusion

In this paper, we presented on the one hand, a functional analysis of the existing weighing system in a grain silo and on the other hand, a conception of an application of supervision that permits the control of the system in order to improve the weighing process of cereals.

This is why the analysis of the weighing system of cereals has been led through a functional and critical analysis of the existing system using the SADT method. Then, we achieved a prototype of supervision of the weighing system that permitted us to control a weighbridge in automatic fashion.

The presented work adopted a pragmatic gait based on a case survey. The elaborate methodology, the developed tools as well as the gotten results incite us to continue in the objective to contribute to develop a strategy of assessment of performances of a weighing system of cereals and help to the decision making.

This analysis will allow an easy stage of a parametric modeling and implementation through the development of a control algorithm helping in the design of a supervising and monitoring system of the weighing system of a grain silo.

Starting from this functional analysis discussed in this paper, work is in progress to develop robust control strategy for a dynamic and automatic control in real time of trucks' dynamic motion on the weighbridge and for similar real cases over the world.

## References

- [1] Hata S. and Anezaki T., Human Friendly Production System, IEEE International Conference on Mechatronics and Automation, 2007.
- [2] Bleux J-M., Maintenance : Systèmes automatisés de production, Etapes, 1998.
- [3] Sticklen J. and William E., Functional Reasoning and Functional Modelling, IEEE Expert: Intelligent Systems and Their Applications, 1991, pp.20-21.
- [4] Larvet P., Analyse des systèmes : de l'approche fonctionnelle à l'approche objet, Inter Editions, Paris, 1994.
- [5] Jaulent P., SADT un langage pour communiquer, IGL Technology, Eyrolles, Paris, 1989.
- [6] Guibert O., Analyse et conception des systèmes d'information : les méthodes, Université de Bordeaux, 2005.
- [7] Ryan J. and Heavey C., Process modelling for simulation, Computers in Industry 57, pp.437-450, 2006.
- [8] Schoman K. and Ross D.T., Structured analysis for requirements definition, IEEE Transaction on Software Engineering, 3(1), pp. 6-15, 1977.
- [9] Santarek K. and Buseif I.M., Modelling and design of flexible manufacturing systems using SADT and Petri nets tools, Journal of Materials Processing Technology, Vol. 76, Issues 1-3, pp.212-218, 1998.
- [10] Goldshtein, M. Matveyev, A., The informal modelling of input-preprocessing subsystems for scientific research, Proceedings IEEE of 10th Digital Signal Processing Workshop, and the 2nd Signal Processing Education Workshop, pp.140-144, 2002.
- [11] Lissandre M., Maîtriser SADT, Editions A. Colin, Paris, 1990.

- [12] Jaulent P., Génie logiciel les méthodes: SADT, SA, E-A, SA-RT, SYS-P-O, OOD, HOOD, Armand Colin, Paris, 1992.
- [13] Dermi A., Contribution à l'évaluation de la fiabilité d'un système mécatronique par modélisation fonctionnelle et dysfonctionnelle. Thèse doctorat, septembre 2009.
- [14] Plateaux, R. Choley, J.Y. Penas, O. Riviere, A., "Towards an integrated mechatronic design process", IEEE International Conference on Mechatronics, ICM 2009, pp.1- 6, Malaga, 2009.
- [15] Lakhoua M.N., Analyse systémique d'un environnement de production en vue d'implanter un système d'information, Thèse, ENIT, 2008.
- [16] Lakhoua M.N., Using Systemic Methods for Designing Automated Systems, International Journal of Applied Systemic Studies, vol. 2, N°4, 2009, pp. 305-318.
- [17] Lakhoua M.N., Systemic analysis of an industrial system: case study of a grain silo, Arabian Journal for Science and Engineering, octobre 2012.
- [18] Skaf A., Etude d'un système de supervision et de commande d'un procédé complexe comme un élément de base d'une organisation distribuée comprenant des machines et des hommes, Thèse doctorat, Grenoble, 2001.
- [19] Hernandez H., Supervision et diagnostic des procédés de production d'eau potable. Thèse de Doctorat, Toulouse, 2006.
- [20] Cottet F., Grolleau E., Systèmes temps réel de contrôle-commande, conception et implémentation, 2005.
- [21] Jbira M.K., Lakhoua M.N., Functional Analysis of Congestion State Caused by Pilgrims Crowd Using SADT Aiding on the Design of a New Supervisory System, JEEE, , 2012.
- [22] Lakhoua M.N., Methodology for Designing Supervisory Production Systems: case study of a counting system of natural gas, Journal of Electrical Engineering, (www.jee.ro), vol. 9, N°3, 2009.
- [23] Lakhoua M.N., Application of functional analysis for the design of supervisory systems: case study of heavy fuel-oil tanks, International Transactions on Systems Science and Applications, Vol. 5, No1, June 2009, pp. 21-33.
- [24] Lopes, Y.K.; Rosso Jr., R.S.U.; Leal, A.B.; Harbs S, E.; Hounsell, M.S. Finite Automata as an Information Model for MES and Supervisory Control Integration. INCOM 2012, 2012, Bucharest. Proceedings of the 14th IFAC Symposium on Information Control Problems in Manufacturing, 2012. v. 14. p. F-488-F-493.
- [25] Hadžiosmanović D.; Bolzoni D.; Hartel H.P., A log mining approach for process monitoring in SCADA, Int. J. Inf. Secur., N° , 2012, 11:231–251.