ISSN 2347 - 3983
Volume 9. No. 2, February 2021
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter13922021.pdf
https://doi.org/10.30534/ijeter/2021/13922021

# Artificial Intelligent Algorithm to control Circuits Structuring of Flexible remote Experiments in Engineering within a Switching Matrix Architecture

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**ABSTRACT**

This paper presents the development of an artificial intelligent algorithm to control circuits structuring of flexible remote experiments in engineering fields of electronics and electricity within a switching matrix architecture. In addition, this paper presents a technical analyze and characterization of VISIR system to point its advantages and its inconveniences. The developed artificial intelligent algorithm controls the interconnections between electrical and electronic components and monitors the power supplying and measurements conducting on VISIR system. We also developed an electronic board to provide the physical possibility of connecting any component to any other component on VISIR's switching system, and thereby manifesting a switching matrix architecture within VISIR.
The developed switching matrix architecture and the developed algorithm enable to have flexible remote experiments in engineering fields of electronics and electricity while having resilient control on circuits structuring for e-learning purposes. In addition, they open the way to have more circuit combinations of experiments by offering the possibility of connecting any component to any other component while respecting the electrical limits of current and voltage.

**Key words:** Artificial intelligent algorithm, electronic board design, engineering remote experiments, flexible circuits structuring, switching matrix architecture.

## 1. INTRODUCTION

The perpetual evolutionary process of development of Information Technologies (ITs) has given born to significant improvements and revolutionary leaps in various fields of business, finance, industries, health, management, communication, education, sport, etc. As a result, educational establishments and learning frameworks have grown and evolved rapidly by adopting the tools and concepts of e-learning and remote experimenting, which is a major outcome of the corporation between telecommunication technologies, educational pedagogies and learning resources [1], [2].

E-learning and online experimenting have become principal aspects and mainstreams in the various fields of education, and they have been massively involved, or even integrated, in higher educational sectors of United Kingdom, United States, France, Russia, Germany, Canada, Australia and other countries from the vast continents around the world.

The quality aspect of provided services of e-learning systems has attract a considerable amount of research work and attempts of evaluation and assessment [3], [4]. A substantial number of researchers and investigators have tried to determine the responsible factors and variables of e-learning success, in order to optimize the potential yield and effectiveness of distance education through internet while relying on these information systems [5], [6].

The major parts of these researches and studies have conducted their assessment processes on different entities and keys of e-learning success [7], each one individually and separately from others; ignoring the significant synergistic impacts of these factors and entities while interacting between them and influencing each other [8]. Moreover, other directions of research and studies have treated the junctions and relationships between the quality factors of e-learning, the usage of e-learning systems and/or satisfaction of their end users such as students, teachers and instructors [9], [10].

The tremendous amount of studies and research papers on distance education, e-learning and online experimenting have considerably contribute in evolving the pivotal success factors of e-learning and educational experiments. From many of these factors, there is the quality of used resources and systems, the quality of provided information and theoretical content , the quality of provided services through the internet, in addition of the interactivity, satisfaction and content usefulness [11], [12]. However, the excessive number of assessments and evaluation measurements among dependent and independent variables presents itself as the main challenge of current researches, toward developing a successful global model of e-learning and online experimenting.

There is a paramount necessity to have a comprehensive model about the multiple levels of e-learning success and their incorporated factors, variables and parameters [8], in order to guide the deployment of successful e-learning systems globally.

E-learning systems are, in essence, web-based information systems that implicate human individuals (such as students, professors and instructors), and nonhuman entities and parts such as learning management systems and educational contents (courses, quizzes, exercises, etc.). It is important to investigate multiple levels and dimensions of successful interactions between the provided resources and educational services on these information systems of e-learning, and their potential benefiters of students and other potential users.

Laboratory's practices of in-place experimenting on physical materials represent the heart and leveraging pillars of engineering education. They open the way to shape and transform the bare knowledge into tangible tools, utilities and technologies exploited to the welfare of their users. There are four principal known categories of experimenting laboratories [13], [14]: hands-on laboratories, simulation based laboratories, virtual labs and remote laboratories.

Hands-on laboratories are the most known and demotic category of laboratories in the fields of education; they require the physical presence of human individuals (students, professors, instructors, etc.) and the experimental instruments and materials at the same local place. They provide their users of students with the clearest tangible experiences at the level of physical interaction and manipulation. However, their financial inconveniences of requiring high monetary investment, requiring more maintenance work and requiring more local spaces and infrastructures; stimulate the consideration of other supplementary resources or even considering alternatives.

Simulation based laboratories and virtual labs are simply imitators, they rely on mathematical models, virtual user-interfaces and software systems, which may weakens the experimental reference to physical interaction with real instruments and equipment; if these resources lack high levels of interactive manipulation and high precision of experiments execution.

Remote labs are physical laboratories, similarly approximated to the previously mentioned category of hands-on laboratories, in addition of supporting online access and remote control on mounted experiments. Their surplus convenience is their exploitability through the internet while providing multiuser-based web services, in order to support large numbers of students or other users. The reduced costs and reduced requirements of local space and maintenance, in addition of time allocation flexibility and provided accuracy of approximations to hands-on experiments, all that represent the most powerful advantages and criteria of strength of remote laboratories over the formerly mentioned categories of laboratories.

In our remote lab, we concentrate on deploying various materials in order to have a hybrid laboratory with versatile resources, where we deploy physical materials for hands-on experimenting and other materials for remote experimenting, in addition of deploying simulated and virtualized practices of online experimenting. Moreover, we focus on developing and deploying flexible resources of software and hardware with various ranges of interactive manipulation. These flexibility is niched by providing the possibility of interconnecting between different circuits and components in different combinations, to experiment in the fields of electronics and electricity while having diverse experiments.

One of the main interesting aspects of nowadays research and innovation in the areas of remote experimenting is developing flexible structures of hardware, where the possibility of interconnecting between diverse discrete components in different combinations. Moreover, concretizing high levels of flexibility and resiliency by providing the possibility of connecting any electrical or electronic component to any other component, while respecting the electrical limits of voltage and current to protect the implicated hardware resources from failure and destruction.

This article presents the work of deploying different resources of hardware for remote experimenting on circuits structuring using VISIR system (Virtual Instrument Systems In Reality) and other equipment such as NI Elvis and Quanser. The principal originality of this paper is presenting an artificial intelligent algorithm, which we developed to control circuits structuring in engineering fields of electronics and electricity while respecting the electrical limits of using the current and voltage during the online experiments on VISIR system. In addition, this article presents the elaboration of a switching matrix architecture within VISIR system by developing an electronic board, to provide the physical possibility of connecting any electrical or electronic component to any other component on VISIR's switching system, which mounts more flexibility and more combinations of experiments on VISIR.

The elaborated switching matrix architecture opens the way to connect any electrical or electronic component to any other component on VISIR's switching system, which provides more resiliency of remote experimenting by supporting more circuit combinations. However, to exploit this elaborated switching matrix architecture and exploit its provided high level of circuits structuring flexibility, we had to develop the artificial intelligent algorithm to be responsible of executing a dynamic control and monitoring on the experiments of circuits building while respecting the electrical limits of current and voltage.

This artificial intelligent algorithm is developed to exploit all the potentials of the elaborated switching matrix architecture while protecting the hardware resources of VISIR system from destruction and failure.

There are many relevant papers of research, which present different works of deploying [15], exploiting [16] or analyzing VISIR system [17], [18]. However, this paper is distinguished from others because it presents a technical analyzing and characterization of VISIR system, in addition of pointing specific limitations and potentials of using VISIR system to deploy online services of flexible remote experiments in the engineering fields of electronics and electricity. Furthermore, this paper is distinguished by presenting our developed artificial intelligent algorithm to control circuits structuring on VISIR, and our developed electronic board to deploy a switching matrix architecture within VISIR's switching system to provide the possibility of connecting any component to any other component.

Without relying on the use of the proposed electronic board in this paper as a solution to deploy a switching matrix architecture within VISIR system, or relying on other potential techniques to deploy a switching matrix architecture, VISIR's switching system is physically unable to provide the possibility of connecting any component to any other placed component on its electronic boards.

VISIR system relies on the use of a limited static method to control and monitor circuits structuring by using files with max extensions (max-files), to describe predefined circuit structures to experiment on VISIR's switching system, which limits the number of supportable experiments in term of circuit combinations.

The use of these max-files by VISIR system limits the number of potential circuit combinations, because each max-file is relied-on to describe and control the building of a specific predefined circuit in term of included components and power supply. Therefore, we developed the artificial intelligent algorithm (Section 4), to offer more flexibility of experiments on VISIR system by supporting more combinations of circuits, which will enable the exploit of all physical prospects of VISIR's switching system and open the way to exploit all offered potentials of the proposed electronic board in Section 5.

This paper is structured as follow: Section 2 presents the deployed projects and resources for e-learning and online experimenting in our remote laboratory. Section 3 presents a technical analyse and characterization of VISIR system. Section 4 presents the developed artificial intelligent algorithm for circuit's remote control and experiments monitoring on VISIR system. Section 5 presents the developed electronic board to provide the techniques of switching and multiplexing in order to deploy a switching matrix architecture within VISIR system. Finally, section 6 for conclusion.

## 2. DEPLOYED RESOURCES FOR E-LEARNING AND ONLINE EXPERIMENTING IN OUR REMOTE LAB

In our deployed remote laboratory, we integrate different resources of software and hardware to concretize our principal subjects and perspectives of distance learning and online experimenting on analog circuits, digital circuits and other fields by relying on versatile materials for remote experimenting. In addition, we managed to adapt many deployed resources to satisfy two major axes of our research. The first major axe of our research is deploying shared topologies of hardware and software for online experimenting to be accessed and exploited by different remote laboratories and educational establishments, and the second axe is adapting various equipment and instruments of hands-on laboratories to online access and remote experimenting through the internet.

From many other projects, web-based services and resources of hardware and software, we deployed VISIR system (Virtual Instrument Systems In Reality) for remote experimenting in the fields of electricity and electronics (Fig. 1). We deployed the iLab architecture for simulated and emulated experiments while relying on the resources of LabVIEW. In addition, we deployed the Moodle platform for distance learning and online experimenting in different educational fields by relying on simulated and virtualized practices. Furthermore, we adapted and deployed other resources of NI (National Instruments), NI Elvis and Quanser (Fig. 2), to be used and exploited through the internet; in order to support the conduction of in-place experiments and remote experiments in electronics of energy.

VISIR system, which is shown in Fig. 1, was started and developed in the Blekinge Institute of Technology [19]. Several other universities, educational institutions and remote laboratories around the world have deployed it, either for their own uses of remote experimenting or for collaborative exploits through their own platforms of e-learning. VISIR system provides an online environment and platform for remote experimenting in electronics and electricity, where it serves similar classical functionalities and behaviours to the usual conducted activities of in-place experimenting in hands-on laboratories, by supporting advanced levels of interactive manipulation while controlling remoted resources of hardware.

The iLab Shared Architecture (ISA) [20] was developed at the MIT (Massachusetts Institute of Technology) in United States of America. It has proved that online laboratory's use and online experimenting environments can, globally, spread and scale to thousands of students around the world. Relying on this type of architectures and web-based platforms enables distant users to access remote laboratories through single sign-on interfaces while using simple administrative services through the internet for twenty-four hours, 7 days a week. This iLab architecture is, currently, outdated and no longer supported by Massachusetts Institute of Technology. However, we are working on extracting its principal integrated functionalities of hosting and exploiting LabVIEW resources, in order to be incorporated or used through other platforms of e-learning management systems such as the Moodle.

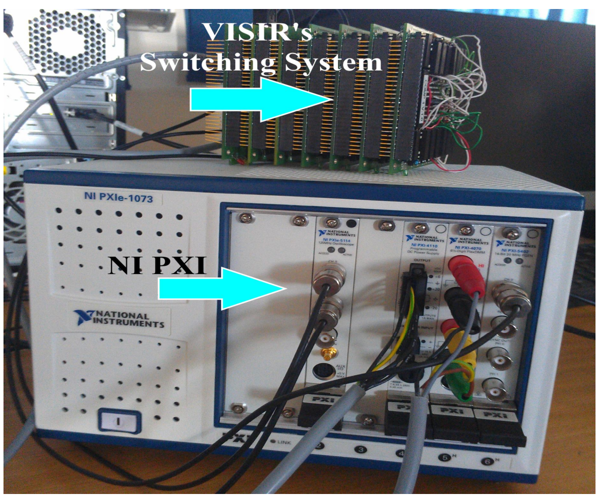


**Figure 1:** Deployed system of VISIR in our remote laboratory


**Figure 2:** Deployed systems of NI Elvis and Quanser in our remote laboratory

We deployed the Moodle platform, which presents one of the most known open-source platforms of content management for e-learning and online experimenting on simulated experiments and virtualized practices, such as by using Easy JavaScript Simulations (EJSS) [21] for online experimenting. The Moodle platform enables the creation of online web-based courses and quizzes, while providing the necessary services of identification and authentication to ensure their online access only to subscribed and enrolled students of concerned educational establishments [22]. This platform allows the communication, the exchange of information and the exchange of educational contents among geographically dispersed users of students and professors; either through asynchronous communication web services such as textual discussion forums and workshops or through web-based synchronous mechanisms such as chats.

We are working on adapting the deployed services of distance learning and online experimenting in remote lab to support online and offline exploit, where potential students, professors and instructors may use them with or without having access to the Internet. Nevertheless, the hardware aspect and used types of technologies are limiting the capacities of the offline service in term of covered geographical zones. Therefore, one of the primary aspects of our research is resolving this limitation by interconnecting Wi-Fi networks, Ethernet networks, and WiMAX networks to provide the offline web-based services of remote laboratory at extendable scales of geographical territories. Even though, these extendable scales impose more risks of cybersecurity on integrated web resources and deployed network architecture, which forces the conduction of further security tests on concerned technologies and implicated resources of software and hardware [23].

In our remote laboratory, we deploy different web-based services of online experimenting and e-learning, as shown in Fig. 4, where we try to support various fields of experimenting while relying on smart management of environment and deploying embedded systems based on Internet of Things (ITs) [24].

In our remote laboratory, there is a deployed server used for the online access to our remote lab (Fig. 3), which aims to serve the essential tasks of introducing all services and entities of our deployed projects of e-learning and online experimenting. In addition, this web-based service of online access forwards the incoming students and guests through internet to all integrated web services and resources of our remote laboratory.

On the web services of our remote laboratory, we deploy the Open Lab platform of VISIR, which supports the principal services and functionalities of identification, authentication and scheduling to experiment in the practical fields of electronics and electricity on VISIR system. Moreover, it handles the integration of theoretical contents of served experiments in form of digital files, while supporting different assessment processes and interaction utilities between professors, students and experiment instructors.

On the web services of our remote laboratory, there is the web-user application of VISIR system, which is deployed on the same server of VISIR's Open lab platform in our remote laboratory. This web-user application of VISIR is dedicated to be served through the internet as a web-user interface, to experiment in the fields of electricity and electronics by supporting circuits structuring and measurements visualization while using approximated shapes to the usual materials and instruments of hands-on laboratory; such as Dual-multimeter, oscilloscope, functions generator, circuits breadboard, etc.

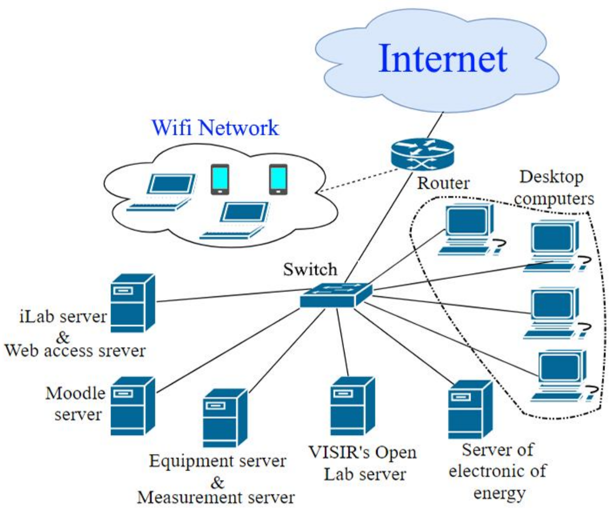


**Figure 3:** Deployed systems and network topology in our remote laboratory

There is the measurement server of VISIR system through the web services of our remote laboratory, which is dedicated to order and manage the received online queries from distant users through internet; such as students, professors, instructors of experiments or visitors. This measurement server is in-charge of receiving the online queries, and then forwarding their contents of requests and commands to the deployed equipment server of VISIR system, in order to apply the requested modifications of parameters and execute the measurements of concerned experiments.

There is the equipment server of VISIR system through our remote lab's web services, which is in-charge of the control and monitoring of the deployed hardware resources of VISIR system. This equipment server is responsible of the next functionalities: applying the online commands and requests of received packets from the measurement server, conducting the requested measurements at the requested points of built circuits, and then forwarding the collected results of experiments to the measurement server in order to be provided to the end-users of online experimenters.

Through the online services of our remote lab, there is a deployed service of remoted experiments in electronic of energy, which aims to control and monitor two embedded systems of National Instruments: NI Elvis and Quanser, which are shown in Fig. 3. We adapted the systems of Quanser and NI Elvis from local exploit to the online experimenting in electronic of energy through the internet, in order to support larger number of experimenters on these two systems nearly simultaneously.

## 3. TECHNICAL ANALYZE AND CHARACTERIZATION OF VISIR SYSTEM

The scenario of interactions and communication between VISIR's hardware and software parts during an experiment session is as described in Fig. 4, where the web-user interface communicates to the measurement server through HTTP (Hyper Text Transfer Protocol) and XML protocols (Extensible Markup Language). The measurement server communicates to the equipment server through port 5001 using HTTP protocol, and the equipment server communicates and controls the hardware field through LabVIEW software manager while relying on NI MAX

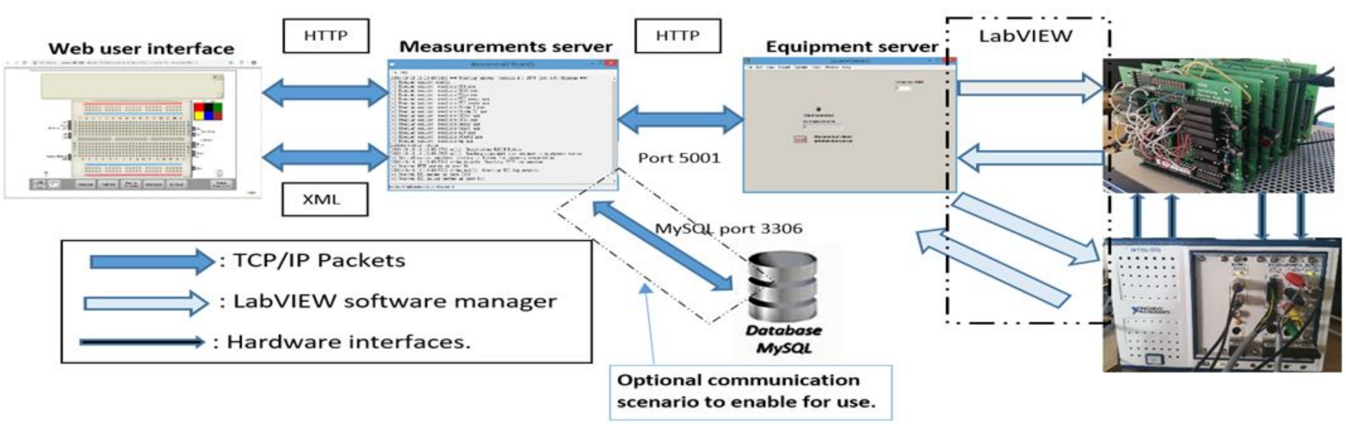


**Figure 4:** Communication scenario between hardware and software parts of VISIR during an experiment.

(National Instrument Measurements and Automation Explorer). The optional communication scenario to use for authentication is where the measurement server is configured to check a database for each incoming experiment session; to verify its authorization to occur and to be served at that time.

After installing the hardware and software parts of VISIR system. Placing electrical and electronic components for the aimed experiments of circuits structuring on the breadboard cards of VISIR's switching system. Declaring and defining these components in the components list-fil used by the equipment server. Declaring the authorized and supported circuits for structuring as max-files to be used by the measurement server. Editing the max list-file to refer the names and paths of all experiments max-files, and editing the library list-file used by the web-user interface to define and display the available component shapes for dragging, manipulating and wiring. Finally, we managed to adapt our VISIR's hosting server to the network of our laboratory, and support its access on our remote lab's domain name through Internet. During all this technical work, we found many advantages, in addition of finding many inconveniences, disadvantages and limitations to be remediated or to be fixed.

Many of these inconveniences, disadvantages and limitations were actually either improved, optimized or resolved in our remote laboratory after deployment and analyzing.

### 3.1 Advantages of VISIR system

The most important and recognizable advantages of VISIR's hardware and software parts, including VISIR's Open lab platform, are as follow:

1. Offering a physical remoted environment of experimenting in term of circuits structuring and measurements conducting, by using and manipulating physical components and measurement instruments.
2. Offering a library list of different types of components to be used in experiments.
3. The possibility to build specific predefined circuits from beginning using discrete components.
4. The possibility to build subcircuits of these specific predefined circuits from beginning, which gives more content of experiments.
5. The possibility of connecting and using, physically, the same component in different predefined circuits.
6. The possibility of measurements conducting at any point of built circuits.
7. Offering different instruments for different power supplies and measurements conducting with large ranges of manipulation, and offering real instrument interactive shapes as web-user interfaces.
8. Offering a breadboard interface for components dragging and wiring for circuits building, similar in shape and use to the real experimental breadboards usually used in hands-on laboratories. It contains different ports of power supplies, DMM ports and oscilloscope channel ports.
9. The supported experiments are defined by using a max-file for each experiment circuit; in order to secure components use and monitor the instruments manipulation.
10. Supporting simultaneous connection sessions from different users relying on a FIFO (First In First Out) waiting line integrated within the measurement server for incoming requests of experimenting.
11. The possibility of adding high numbers of experimental components by adding more switching breadboard cards (component cards) on the switching systems of VISIR.
12. Categorizing the supported components by: type name, product serial and electrical/electronic values.
13. Handling the support of theoretical contents, such as by using documents, for the available experiments on VISIR's Open lab platform.
14. Supporting the saving and loading of elaborated circuits on the web-user interface.
15. Offering the choice of having a verified session mode, where the measurement server verifies the credentials of each user request whether he is authorized to conduct his experiments at that time or not. Otherwise, choosing the non-verified session mode, where the measurement server forwards directly the data and commands of the received requests to the equipment server for experiments execution.

### 3.2 Inconveniences and limitations of VISIR system

The principal confronted limitations and inconveniences while installing, deploying and using the hardware and software parts of VISIR, are as follow:

1. VISIR's switching system does not offer the physical techniques of a switching matrix structure. Therefore, it does not offer the physical possibility to connect any component to any other component.
2. To add more interconnection possibilities between the components on the switching breadboard cards of VISIR for more combination possibilities, we need to add more shortcut wires, which is a wasting use of more component nodes.
3. The possible experiments are defined by using a max-file, at the software level, for each experiment circuit for its monitoring; which is a static method to use. Relying on these max-files introduces an added limitation of supported circuits in function of possible combinations and interconnections between offered components.
4. If the used hosting machine of the switching system was chuted down and rebooted, the equipment server may not start working properly; because the attributed serial USB name and attributed number to the switching system on NI MAX (NI Measurement and Automation Explorer)

would be changed. Therefore, we would have to edit the equipment list file used by the equipment server to identify the used materials, in order to change the USB serial of VISIR's switching system to the new attributed one.

5. The obligation of using a non-signed certificate fil for the switching system's USB port; in order to enable the hosting machine to identify and exploit the switching system of VISIR. The hosting machine will not accept this non-signed certificate file until editing its software manager to authorize, permanently, the use of non-signed certificates.
6. Each package of the Open lab platform and the web-user interface of VISIR must be downloaded separately, and they must be configured using textual commands and codes editing according to predefined steps. Many confronted obstacles and stacked-in problems during their installation processes need online research and forums crawling for provided solutions. Otherwise, consulting VISIR's familiar developers (or deplorers) for advice or help, or conducting personal efforts and improvise for alternative configurations and find any missing clues to move forward.
7. The web-user interface of VISIR does not work through SSL certified connections under the HTTPS prefix of used URLs (Uniform Resource Locator). Therefore, we needed to conduct manual crawling and searching for the corresponding files to remove the HTTPS prefix used for the web user interface, and replace it with HTTP prefix for non-SSL certified connections.
8. VISIR's Open lab platform uses non-defined variables for the location paths of the user interface files and the measurement server. Therefore, we needed to search, manually, the files that use those variables and change their values to the absolute paths.
9. The necessity of installing and deploying a hall licensed version of LabVIEW platform, which means a purchased version with its integrity of hardware drivers, its NI MAX for drivers managing and its platform libraries. Purchasing this hall version of LabVIEW aims to identify and use the switching system and the PXI product with its instrument modules, and run properly the equipment server's sub-VIs with no errors of missing functionalities, missing files and libraries, or errors of non-compatible drivers.
10. The measurement server entity needs more configurations and adaptation to work on its own hosting machine, independently and separately from the host of the web-user interface of VISIR.

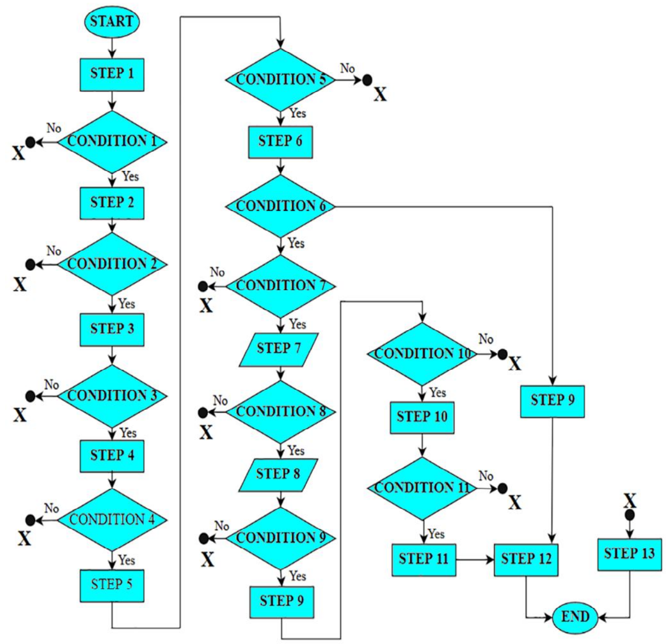


**Figure 5:** Developed artificial intelligent algorithm for the control of circuits structuring on VISIR system

## 4. DEVELOPED ARTIFICIAL INTELLIGENT ALGORITHM FOR REMOTE CONTROL OF CIRCUITS STRUCTURING IN ENGINEERING

We developed an artificial intelligent algorithm (Fig. 5) in order to control and monitor the remote experiments of circuits structuring on VISIR system. This developed algorithm is proposed as an alternative to using the max-files; in order to monitor the circuits building and measurements conducting of each potential experiment on VISIR's switching system [25], [26].

The presented algorithm in Fig. 5 is intelligent because it is based on a wide interval of decision making while relying on numerous processes of calculation [25], [26].

This developed algorithm is based on decision handling to have a smart machine control [27] on VISIR system, whereas relying on automated processes of human-logic and constructive analyzing on circuits structuring which make it artificially intelligent.

This artificial intelligent algorithm offers more resiliency and flexibility to establish the physical interconnections between electrical and electronic components on VISIR's switching system, instead of relying on the max-files. These max-files present a limited static method where there is only the possibility of building predefined structures of circuits in the engineering fields of electronics and electricity, or build portions of those structures as subcircuits. Therefore, this artificial intelligent algorithm is developed to surpass the limitation of using max-files by providing more flexibility and freedom of circuits structuring on VISIR's switching system while respecting the electrical limits.

This developed intelligent algorithm, which is shown in Fig. 5, offers a dynamic method of control and monitoring during components interconnecting and circuits building on VISIR system, while respecting the electrical and electronic limits such as the maximum values of voltage and current, in addition of controlling the supportable power supplies and measurements execution.

This artificial intelligent algorithm relies on organized steps to control and test the requested components and circuits for experimenting before supplying them with any source of power, in order to avoid any electrical risks. In addition, this algorithm is based on a structured logic [27] of components interconnecting where, as an example, each output of a component should not be connected to the input of the same component; neither directly nor indirectly. Furthermore, this developed algorithm is based on respecting the limits of maximum supportable values of current and voltage of the electronic boards of VISIR's switching system and also the electrical limits of used measurement modules of NI PXI.

Generally, it will be more convenience to incorporate the use of this algorithm with the use of the max-files of VISIR system, to provide a more controlled environment of experimenting and reduce the amount of necessary calculations when having more composed circuits, in order to open the way to serve high numbers of online experimenters on VISIR's switching system.

Instead of integrating learning processes within this developed algorithm, we rely on the repeated logic and patterns of reasonable conditioning on circuits building, to avoid consuming more storage space for the data of circuit structures and the potential interconnections between their components. Moreover, this algorithm is developed to exploit all the potentials of the physical switching techniques of VISIR by avoiding the necessity of having a max-file for each supportable experiment. Furthermore, this algorithm opens the way to exploit the potentials of integrating a switching matrix architecture within VISIR's switching system by relying on the proposed electronic board shown in Section 5. Therefore, relying on the use of this developed artificial intelligent algorithm along with the proposed electronic board in Fig. 6 offers the possibility to connect any electrical or electronic component to any other component placed on the component cards of VISIR's switching system.

This proposed artificial intelligent algorithm is based on multiple steps and conditions of experiments conducting. The executed step processes of this algorithm, which are shown in Fig. 5, are as follow:

- STEP 1: Defining all implicated components in the requested circuit structure.
- STEP 2: Determining each connection of two-ends between the components of requested circuit structure.
- STEP 3: Defining the entries and the ends of the circuit.
- STEP 4: Determining each output of each component and its successive component.
- STEP 5: Determining each output of each component and its successive series of circuits.
- STEP 6: Determining the used power source at the entry of circuit.
- STEP 7: Determining the values of voltage between the inputs and outputs of implicated components.
- STEP 8: Calculating the value of electrical current, which is going to be absorbed by the entire circuit.
- STEP 9: Building the requested circuit without power supplying.
- STEP 10: Testing the ends of built circuit to avoid electrical risks.
- STEP 11: Providing the built circuit with power supply.
- STEP 12: Conducting the requested measurements on the built circuit.
- STEP 13: Rejecting the execution of requested experiment.

The transitional conditions of this artificial intelligent algorithm, which are presented in Fig. 5, are as follow:

- CONDITION 1: Verifying that all implicated components in requested circuit are actually placed on the switching system of VISIR.
- CONDITION 2: Verifying that each interconnection between two ends of two different components of requested circuit is supported on VISIR's switching system.
- CONDITION 3: Validating that if the entries of requested circuit are connected to any source of power, then the ends of that circuit should be connected to the ground.
- CONDITION 4: Verifying that the output of each used component in requested circuit is not directly connected to the input of the same component.
- CONDITION 5: Verifying that the output of each used component is not indirectly connected to the input of the same component.
- CONDITION 6: Verifying whether the circuit is implicating the use of certain power source, or is it not relying on any power supply?
- CONDITION 7: Verifying whether the requested power supply of concerned experiment is physically supported for the requested circuit, or is it not supported for that specific circuit?
- CONDITION 8: Verifying that the used voltage value of validated power source is inferior than the maximum supportable voltage by VISIR's switching system.

- CONDITION 9: Verifying that the absorbed value of electrical current from the implicated power source is going to be less than the maximum supportable current by the electronic cards of VISIR system.
- CONDITION 10: If all conditions are validated, then accepting to build the requested circuit without power supplying.
- CONDITION 11: Testing the ends of built circuit to determine whether they are secure to be power supplied without electrical risks, or are they at risk to be damaged?

On one hand, the shown algorithm in Fig. 5 processes each physical component in term of its type, its components card that it is placed on, its component nods that it occupies, its wiring nodes that it is connected to and its electrical value (or its electronic characterizing value). On other hand, this algorithm processes the components of each virtually elaborated circuits by online experimenters in term of their types, their interconnections, their electrical values and their electronic characterizing values before passing to the physical level of analyzing in order to validate the physical possibility of building the requested circuits on VISIR's switching system.

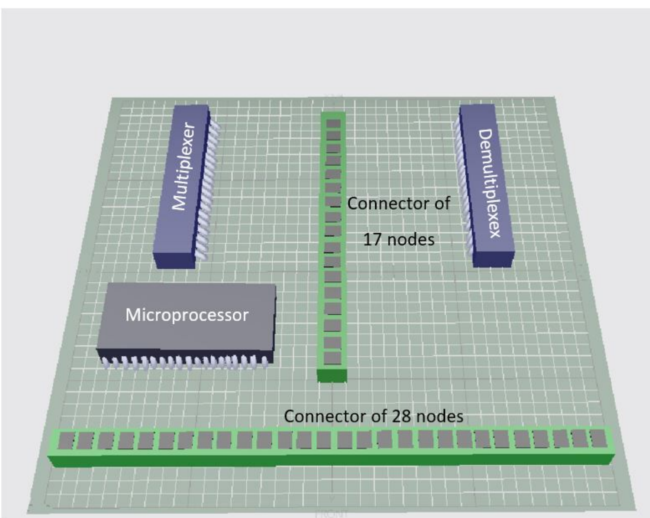


**Figure 6:** Structure of developed electronic board to elaborate a switching matrix architecture for circuits building within VISIR's switching system

## 5. PROPOSED ELECTRONIC BOARD TO DEPLOY A SWITCHING MATRIX ARCHITECTURE WITHIN VISIR SYSTEM

Since the switching system of VISIR does not support the physical possibility of connecting any electrical or electronic component to any other component; we developed an electronic board to provide the needed techniques of switching and multiplexing, in order to concretize a switching matrix architecture for analog circuits structuring within VISIR's switching system.

The developed electronic board in Fig. 6 consists of the next elements:

- Connector of 28 nodes, which is used to support the copper branches band that transfers the control data between VISIR's electronic boards.
- Connector of 17 nodes, which is used to support the band of copper branches that circulates the electrical signals between VISIR's electronic boards and the proposed electronic board.
- Electrical Multiplexer, which is used to select two electrical signals of two wiring nodes at its inputs and forward them to its outputs.
- Electrical Demultiplexer, which is used to forward two electrical signals at the inputs of this Demultiplexer to two wiring nodes at its outputs. The output wiring nodes are selected arbitrary according to the necessities of requested experiment.
- Microprocessor, which is relied-on to process the received data at the level of the copper branches band of data communication, in addition of controlling the use of integrated multiplexer and demultiplexer.

VISIR's switching system supports only the structuring of predefined circuits, or their subcircuits, from scratch while relying on direct connections of physical wires to the same wiring nodes or relying on indirect wiring connections of shortcut wires. Therefore, this developed electronic board is responsible of interconnecting between any two components that do not have neither direct connections nor indirect connections to each other on the electronic boards of VISIR system. As a result, this proposed electronic board opens the way to, physically; connect any end of a placed component on VISIR's switching system to any other end of a different component on the same system.

This developed electronic board is integrating the essential techniques of switching and multiplexing, in order to offer the possibility of interconnecting between any two wiring nodes on the switching system of VISIR. Thereby, we will be able to interconnect between any two components on VISIR system, even if they have neither direct wiring connection nor indirect connections of shortcut wires.

The conditioning of circuits structuring on VISIR system, at the level of electrical and electronic limits of experimenting, will be logically supported by relying on the developed artificial intelligent algorithm shown in Fig. 5; in order to provide more resiliency and flexibility of experimenting by supporting more interconnections between the placed components on the switching system of VISIR.

This proposed electronic board, which is shown in Fig. 6, is developed to manifest a switching matrix architecture within

VISIR's switching system, which will offer more potential combinations of circuit structures and more experiments to conduct. This electronic board is developed also to reduce the monetary cost of adding more breadboard cards on VISIR's switching system which are used to mount more shortcut wires or more components redundancy.

## 3. CONCLUSION

This paper proposes an artificial intelligent algorithm responsible of the control of circuits structuring and measurements conducting on VISIR system while respecting the electrical limits of hardware, in order to provide more flexibility of experiments in term of circuit combinations. In addition, this algorithm opens the way to exploit the physical potentials of having a switching matrix architecture within VISIR after deploying the proposed electronic board in this paper on VISIR's switching system.

The proposed algorithm in this paper aims to replace the max-files used by the measurement server of VISIR, in order to have more resiliency of circuits structuring. However, combining the use of this algorithm along with the use of these max-files will provide a more controlled environment in term of security. In addition, their incorporation will be useful in term of speed of experiments conduction when online experimenters request highly composed circuits.

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