3rd International Conference on Automation, Control, Engineering and Computer Science (ACECS'16)
Proceedings of Engineering & Technology (PET)
pp. 83-88

Data decryption temperature sensor used in radiotherapy services applying neural networks

K. LAMAMRA
Department of Electrical Engineering,
University of Larbi Ben Mhidi, Oum El Bouaghi, Algeria.
l_kheir@yahoo.fr

A. ALLAM
Division of Architecture and Multimedia Systems
Advanced Technology Development Center
City of the August 20, 1956, Baba Hassan, Algiers, Algeria
allam@cdta.dz

M. AFIANE
Radiotherapy Department
Hospital Centre Pierre and Marie Curie
1, avenue Bouzenad Salem, place of May 1st, Algiers, Algeria
m.afiane@gmail.com

***Abstract*— In this paper, we present a practical part of work that we have begun to realize for several months and is planned for several steps. In this paper we present the part devoted to decryption of coded data from a temperature sensor of type MS6503 used in radiotherapy rooms of the hospital HCPMC (Hospital Centre Pierre and Marie Curie), the aim is to check remotely the temperatures of the rooms to trigger alarms and his control thereafter in order to avoid mistakes of manipulation which are deadly for patients if they happen or arise.**

Keywords—Data decryption; temperature sensor; radiotherapy rooms control, neural networks.

I. INTRODUCTION

In radiotherapy services, treating patients requires constant vigilance and following with great attention. It is extremely important to be ensure that the conditions in which the patient is exposed are well in order to avoid any risk, This concerns several individuals who have relationship with it (physicians, technicians, physicists and manipulators) to take care and to treat patients by using dangerous devices like linear accelerators [1][2]. It is hard to control all those persons and checking every day the state and quality of equipment [3]. For example, the medical, physicist and technical staff of the radiotherapy service of “Hospital Centre Pierre and Marie Curie (HCPMC) of Algiers” is composed of fifty peoples. In this paper we present a part of a system that we have realized to help avoid errors of manipulation and management. It improves the quality of services and increases the medical care while applying some medical, technical and physical procedures. These procedures should be applied by the personnel of the radiotherapy service. The carried work permits the application of these procedures.

The main purpose is to avoid mistakes of manipulation. These errors are deadly for patients if they happen or arise. such errors and accidents can occur even in developed countries [4][5][6]. Currently, the problem of the quality of services and the accidents in radiotherapy services in the world are not solved [7][8][9]. The first version of this system is implemented in the radiotherapy service of the hospital CPMC in Algiers [4][10]. In this paper, we present the acquisition of temperature data delivered by the temperature sensors used in radiotherapy rooms of the hospital and the way to decrypt by neural networks type Multi Layer Perceptron (MLP).

The temperature sensor used in the CPMC hospital radiotherapy rooms is of type MS6503. In order to display the temperatures value through a specific application that we implemented practically in the aim to control these rooms, this has caused us a major problem because the received data from the sensor are encrypted, which makes direct use is not possible, that require us to seek for an approach to decrypt the data for having the exact values of the temperature of the room radiotherapy, for this we used neural networks trained by back-propagation algorithm to decrypt the data from the sensor. the choice of neural networks is made that the among the advantages of a neural network is its ability to adapt to the conditions imposed by any environment, and ease to change its parameters (weight, number of neurons, etc ....) depending on the behavior of its environment [11][12][13][14][15].

This paper is organized as follows: in the second section we present the wired sensors network platform, in the third section we present the setup of the wired sensors network, and in the fourth section we present data decryption using neural network, and finally in the fifth section we present the results of the developed approach.

II. WIRED SENSORS NETWORK PLATFORM

The computer system consists of five personnel computers, one server computer, three linear accelerators (VARIAN model), two scanner simulators (VARIAN and General Electric), five temperature and humidity sensors for the four radiotherapy cure rooms [16][10].

Computers are placed in a network and three of them are used to control the check list of the apparatus (linear accelerators). These three computers are put outside the cure rooms. The server computer is used as a data server in order to store all data of the system (the check list of the devices, the temperature and the humidity data, physicians and patients' management).

Four personnel computers are devoted to the manipulators (physicians, physicists and technicians) to seize medical information about patients during sessions of the simulation and radiation treatment and their contact details and any other necessary information.

The service head or the technical manager of the radiotherapy services could control and supervises all machines room in only one computer screen, because of one computer among the four is used to view all the screen of the four computer linked to the four cure rooms in one big screen working in real time (active multiple windows). One computer is linked to the two simulation room.

In cure rooms, five temperature and humidity sensors are used with serial RS232 port. The RS232 port is applied inside the four cure and simulation rooms with the three linear accelerators and the two scanner simulators. This system is used in order to improve the quality of services and to increase the medical care. In fact, In fact, through this system and using simple medical, technical and physical procedures and also checking application, we can avoid handling errors that could kill or make disabled patients.

III. Setup of the Wired Sensors Network

A primary version of our control application of temperature treatment rooms is implemented and one of the application interfaces is presented in figure 1. In this application version we made the design of verification and control of some physical and medical procedures and the implementation of all temperature sensors and humidity treatment rooms. The scientific and technical cooperation with the medical staff of the HCPMC's radiotherapy service (physicians and physicists), the technicians of CDTA centre (Centre de Développement des Technologies Avancées) and with contribution of researchers from the University of Oum el Bouaghi of Algeria has led to this solution.

The real time control of the three cure rooms and the simulation room in one screen (multiple screen solution) achieved by using the LabVIEW software is shown in figure 1. LabVIEW is a graphical programming platform suitable for systems of all sizes, from the design phase to the test. Its ability to integrate with existing software and old generation equipment is unmatched, while taking full advantage of the latest computer technology. LabVIEW provides the tools to solve current problems, and offers the ability to innovate faster and more efficiently [17][18][19].

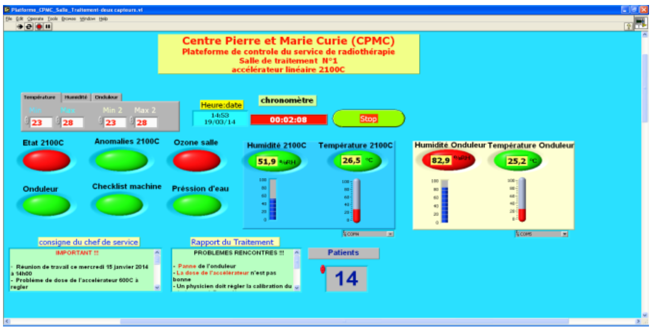

Fig. 1. Real time control of one cancer treatment room

Radiotherapy treatment procedure utilizing radiation play a central role in modern health care. To ensure maximal benefits and minimal risks, it is essential that these techniques rely on adequate dosimetry and medical physics procedures. The dosimetry refers to the accurate measurement of radiation doses and it is essential to enable patients to receive proper medical treatment. In therapeutic procedures, accurate dose measurement is critical for effectively treating patients. The ARIA (trademark of VARIAN Medical System) oncology information system of VARIAN (registered trademark) which links the 3 linear accelerators (VARIAN models), the 2 scanners simulators and the PC'S network medical control procedures is used in the HCPMC's radiotherapy service. This system doesn't guaranties mistakes of manipulations and human fatal errors for the patients' treatment. Our control platform runs in parallel with this system but it's not physically linked with it in order to control and to ensure that the all procedures (physical, medical and technical) are executed without errors by the staff of the medical oncology department. This control platform is complementary to the ARIA oncology information system [4][10].

IV. Data Decryption Uising NN

The temperature sensor used in the HCPMC hospital radiotherapy rooms is of type MS6503, and the temperature display via a computer with a personal application presents a problem because it has a non-transparent communication protocol because the sensor is provided with a specific software that lets you read the temperature and humidity, but if the user needs to integrate the sensor into another application like making monitoring a room, he can not read the data sent by the sensor via the RS232 serial port because its protocol and data format provided by the latter are unknown, the data received through this port are encrypted and encoded and manufacturer keeps confidential secret. To solve this problem and help recover the real values of the temperature of the room we opted to use MLP neural networks trained by back-propagation algorithm to decrypt data (figure 2) [20][21][22][23].

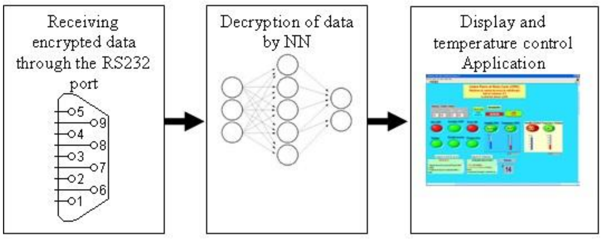

Fig. 2. Decryption of data received through the RS232 port by neural networks

The neural network used for decrypting the data from the sensor is used in two stages. The first phase is a training phase: in this phase the network is adjusted and formed according to its error. In this phase we have trained neural network on a set of data using encrypted codes sensor as inputs of the network and the target is the temperatures corresponding to these codes, these temperatures are noted directly and manually from the sensor placed in a radiotherapy room, these values are read directly through the LCD screen that provides sensor (figure 3), this work is very delicate and tiring and we took a very large time.

Fig. 3. Sensor used in radiotherapy room with LCD screen

The second phase is the validation phase, in which a further set of encrypted data of the sensor are used at the input of the network (data that were not used in the first phase) and the target are the real values of the temperature also manually noted from the sensor screen in the radiotherapy room.

In this phase we aim for verifying the quality of the neural network to decode the sensor data, because at this stage we do not act on the training of the neural network, and we use the same network after training and constructing in the first phase. At this stage, the neural network could be used directly to determine the temperatures corresponding to the encrypted codes received from the sensor through the RS232 port of the computer of control room.

V. Results and Discussions

After building and training of the decryption network of data codes received from the sensor of the radiotherapy room, the neural network is then implemented and connected to the temperature control application of the radiotherapy room that we designed in practice.

To check the reliability and efficiency of the neural network to decrypt the codes for the temperatures remotely recorded; we have opted to choose a wide range of temperature values by applying to the sensor, temperatures ranging from 0°C to 35°C. We note that according to some experts in radiotherapy, temperature in radiotherapy room should not drop below 20°C and should not exceed 25°C. The number of recorded temperature data and the decoded data is 300; these data have been sorted in ascending order.

The neural network structure is as follows: the output layer is composed of a single neuron and it corresponds to the temperature values decrypted by the neural network (*Tnn*). The input layer is composed of two neurons; the inputs of the network are encrypted codes from the sensor (*Cs*) and the instantaneous error (*ei*) which is the difference between the real temperatures (*Tr*) recorded manually from the sensor's screen and the temperature values decrypted by the neural network (*Tnn*). The network consists of a single hidden layer, the number of neuron in this layer is chosen by temptation (trial and error) (*ei*=*Tr*-*Tnn*).

In the figures below, we only present the validation results of the neural network as training results are almost identical. Figure 4 shows the real temperatures measured directly from the sensor (*Tr*) and decrypted Temperatures remotely by neural network (*Tnn*).

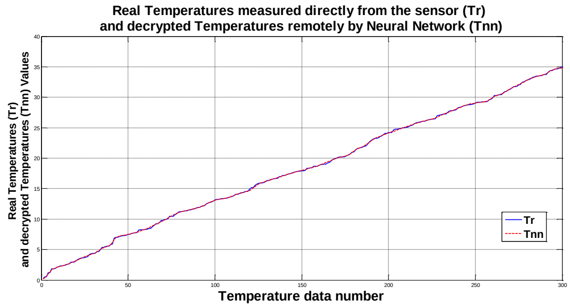

Fig. 4. Real Temperatures measured directly from the sensor (Tr) and decrypted Temperatures remotely by Neural Network (Tnn)

Figure 5 is a zoom in of figure 4, in order to show a portion of the difference between the real temperatures (*Tr*) and decrypted.

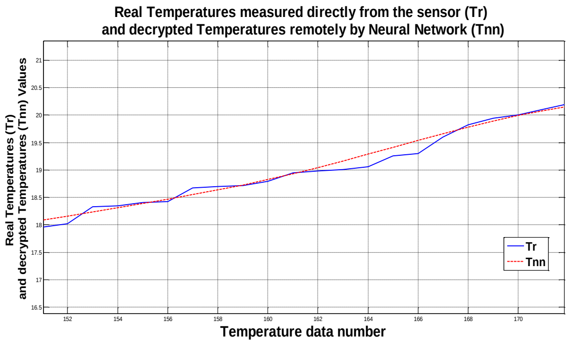

Fig. 5. Zoom in of figure 4, (portion of the difference between the real temperature (Tr) and decrypted)

Figure 6 represents the instantaneous error, and figure 7 shows the quadratic error.

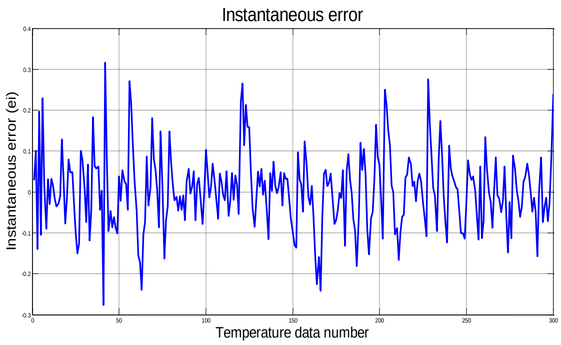

Fig. 6. The instantaneous error

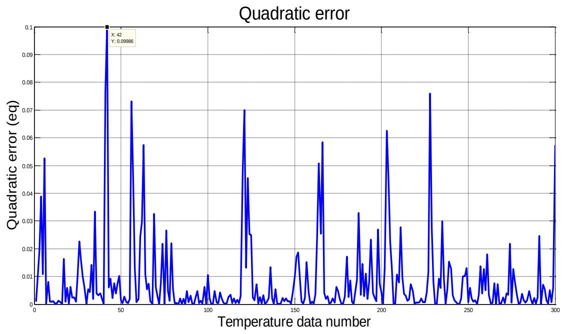

Fig. 7. The quadratic error

The obtained results shows that the global accumulated quadratic error ($eqc = \sum_{k=1}^{n} e_i(k)^2$ with, n: number of data) is equal to *eqc=2.5212*. We note that a maximum instantaneous squared error occurred in the encrypted code number 42 with a temperature error equal to $eq_{max}=0.0998$, and the second biggest error appeared in the encrypted code number 228 with a temperature error equal to *0.0759* (figure 7).

These error values are acceptable. These results show clearly that the neural network was able to decode the encrypted code of the sensor, effectively. We consider these practical results very satisfactory.

VI. Conclusion

In this work we have presented a part on deciphering coded data from a MS6503 type of temperature sensor used in radiotherapy rooms of the hospital HCPMC (Centre hospitalier Pierre et Marie Curie), the goal is to remotely check the temperature of the rooms and triggering alarm and control thereafter.

Using directly data's received from the sensor through the RS232 port was not possible, because the data are encrypted in an unknown way; it's the reason which pushed us to seek an approach to solve this problem. For this we used MLP neural networks trained by back-propagation algorithm to decrypt the data.

This work, which lasted several months, shows that an important step in our control room project is completed successfully and the obtained results are very satisfactory.

References

[1] P. Ortiz López, « Tools for risk assessment in radiation therapy », *Ann. ICRP*, vol. 41, nº 3, p. 197–207, 2012.

[2] P. Ortiz, J. M. Cosset, O. Holmberg, J. C. Rosenwald, P. Dunscombe, L. Pinillos, J. J. Vilaragut, et S. Vatnitsky, « A report of preventing accidental exposures from new external beam radiation therapy technologies », *ICRP*, vol. 39, nº 4, p. 1‑86, 2009.

[3] B. A. Fraass, « Errors in radiotherapy: motivation for development of new radiotherapy quality assurance paradigms », *Int. J. Radiat. Oncol. Biol. Phys.*, vol. 71, nº 1, p. S162–S165, 2008.

[4] A. Allam, S. Oussalah, B. Khiter, S. Ferhat, M. Afiane, et B. Hocini, « Quality control system for radiotherapy services », in *Networking, Sensing and Control (ICNSC), 2013 10th IEEE International Conference on*, 2013, p. 7–10.

[5] O. Holmbert, « Accident prevention in radiotherapy », *Biomed. Imaging Interv. J.*, vol. 3, nº 2, avr. 2007.

[6] G. G. Eichholz, *Accidental overexposure of radiotherapy patients in Bialystok*. LWW, 2004.

[7] S. E. D. F. MÉDICA, « The accident of the linear accelerator in the Hospital Clinico de Zaragoza », *SEFM Madr.*, 1991.

[8] M. Abdel-Wahab, E. Rosenblatt, O. Holmberg, et A. Meghzifene, « Safety in radiation oncology: The role of international initiatives by the International Atomic Energy Agency », *J. Am. Coll. Radiol.*, vol. 8, nº 11, p. 789–794, 2011.

[9] M. Boadu et M. M. Rehani, « Unintended exposure in radiotherapy: identification of prominent causes », *Radiother. Oncol.*, vol. 93, nº 3, p. 609–617, 2009.

[10] A. Allam, A. Baghradji, S. Oussalah, B. Khiter, S. Ferhat, B. Hocini, et others, « Control platform for radiotherapy services », in *Computer and Information Technology (WCCIT), 2013 World Congress on*, 2013, p. 1–4.

[11] N. Nikdel, P. Nikdel, M. A. Badamchizadeh, et I. Hassanzadeh, « Using Neural Network Model Predictive Control for Controlling Shape Memory Alloy-Based Manipulator », *IEEE Trans. Ind. Electron.*, vol. 61, nº 3, p. 1394‑1401, mars 2014.

[12] F. Grasso, A. Luchetta, S. Manetti, et M. C. Piccirilli, « System identification and modelling based on a double modified multi-valued neural network », *Analog Integr. Circuits Signal Process.*, vol. 78, nº 1, p. 165‑176, janv. 2014.

[13] D. S. Levine et M. Aparicio IV, *Neural networks for knowledge representation and inference*. Psychology Press, 2013.

[14] K. Lamamra, K. Belarbi, et S. Boukhtini, « Box and Jenkins non linear system Modelization using RBF Neural Network designed by NSGAII », *Int. Conf. Control Eng. Inf. Technol. CEIT'14 Monast. Tunis.*, 2014.

[15] K. Lamamra et K. Belarbi, « Comparison of Neural Networks and Fuzzy Logic Control Designed by Multi-objective Genetic algorithm », *IJACT Int. J. Adv. Comput. Technol.*, vol. 3, nº 4, p. 137–143, 2011.

[16] J. O. Lubenau et J. G. Yusko, « Radioactive materials in recycled metals », *Health Phys.*, vol. 68, nº 4, p. 440–451, 1995.

[17] J. C. Chen, P. Xie, et L. Pang, « Application of Virtual Instrument Technology in Mine Hoist Control Based on the LabVIEW », *Adv. Mater. Res.*, vol. 881, p. 1714–1718, 2014.

[18] F. Tao, P. A. Mu, et S. G. Dai, « The Research on the Motion Control of Industrial Robots Based on LabVIEW », *Appl. Mech. Mater.*, vol. 433, p. 117–120, 2014.

[19] J. Travis et J. Kring, *LabVIEW for Everyone: Graphical Programming Made Easy and Fun (National Instruments Virtual Instrumentation Series)*. Prentice Hall PTR, 2006.

[20] P. Xie, M. Bilenko, T. Finley, R. Gilad-Bachrach, K. Lauter, et M. Naehrig, « Crypto-Nets: Neural Networks over Encrypted Data », *ArXiv Prepr. ArXiv14126181*, 2014.

[21] I. Fiete, D. J. Schwab, et N. M. Tran, « A binary Hopfield network with 1/log(n) information rate and applications to grid cell decoding », *ArXiv Prepr. ArXiv14076029*, 2014.

[22] A. Baheti, L. Singh, et A. U. Khan, « Proposed Method for Multimedia Data Security Using Cyclic Elliptic Curve, Chaotic System, and Authentication Using Neural Network », in *Communication Systems and Network Technologies (CSNT), 2014 Fourth International Conference on*, 2014, p. 664–668.

[23] P. Ganesan, R. Venugopalan, P. Peddabachagari, A. Dean, F. Mueller, et M. Sichitiu, « Analyzing and modeling encryption overhead for sensor network nodes », in *Proceedings of the 2nd ACM international conference on Wireless sensor networks and applications*, 2003, p. 151–159.