A new approach for Automatic anomalies detection and data correctness Applied to Ambulatory Surgery process

Application in Ambulatory Surgery

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***Abstract*—The applicative context within which our work is that of setting up a training system (serious game) based on augmented reality and constraint programming allows each trainee surgeon or health staff to prepare and in parallel benefit of his theoretical training, training in the anatomy laboratory or experimental surgery for medical or surgical scenarios and technical skills of ambulatory surgery.**

These latter will practice on a simulator having computer-controlled sensors, a teacher or support personnel pre-sets vital signs and physical examination data (auscultation, ...) and will evolve, if necessary, depending on therapeutic interventions. Learning through simulation, widespread, allows, without any risk to patients, to intervene on several elements of surgical training.

This expert system to help decision for Assistance in action during operations reacts to the detection of critical or unexpected situation including deviations or malfunctions in the process by alerting users. This technology can be used to clarify their actions in real time and therefore the target to operate. In doing so, it can optimize the time spent on an operation with very high certainty, or as a validation test of technical ability in the virtual surgery. This system uses 3D scanning that now allows creating real virtual clones of the human body.

In this context, we are interested in the introduction of the new model of the surgical process which represents a large algorithmic complexity, we will also put in place a Bayesian network structure for improved performance both in detection and correction of anomalies found which allows perform through inferences, knowledge analysis with a degree of uncertainty.

Keywords— Ambulatory Surgery, Risk Management, Expert System, business processes, virtual reality, constraint programming, Bayesian networks...

I. INTRODUCTION

A system such as the human body, consisting of a large number of elements to various forms, gives rise to the problem of the complexity of data to be processed. We now understand the difficulty that arises for all who teach, particularly in the field of professions surgery.

Traditionally, students have learned to practice surgery in a clinical setting under the supervision and responsibility of a qualified surgeon. It is expensive, takes time and results in varying effectiveness. The computerized virtual reality simulators are beginning to be appreciated because they give trainees the opportunity to practice their skills in a virtual environment that is safe.

II. GENERAL OBJECTIVES

This research is part of an overall approach of strengthening practical support for quality improvement devices and safety of patient care within health facilities.

It would be possible to implement an active and innovative educational program based on experiential learning and reflective practice. This simulation program is a training program and analysis of practice and research using 3D simulation. It may, depending on the themes and objectives, include other methods (lectures, practical workshops, etc.). In

all cases, instead of simulation in this program should be determined by supply more educational value compared to other existing methods.

It would be possible to create virtual patients with pathological cases may be rare that all students have the chance to deal with these cases at least once before being confronted in reality.

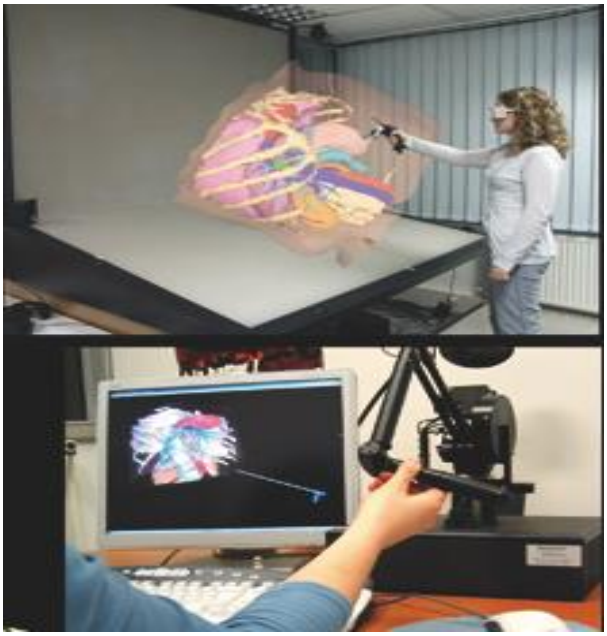

Figure 1. Simulation chirurgical 3D

To respond to problems presented in the previous section, we'll look at the implementation of an aid to learning surgery tool. This type of system is to display to the user that the necessary objects and related information, all in good time, to make them clearer presentations.

This article focuses on the simulation of surgical activities, and aims to show the interest of medical simulation and subsequently provide a reliable educational tool available to trainee surgeons to enable them good learning and good practice of the profession and improves the technical skills of surgical trainees.

III. THE PROJECT CONTEXT

Our work fits particularly in the efforts made by several health institutions to develop Ambulatory surgery is a very sensitive surgical procedure performed in the day under anesthesia variable mode, which does not require the maintenance of patient accommodation at night. This practice in development for two decades is made possible by significant advances.

Ambulatory surgery, as its definition indicates is based on strict rules and internship surgeons must know and perfectly mastered, including the implementation of good practices.

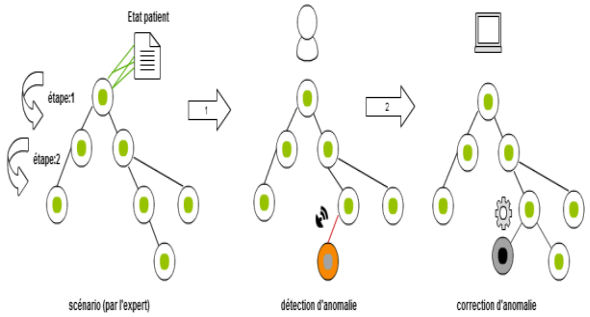

Figure 2. General diagram of the application

Our system uses a knowledge base made by medical experts, by giving all possible scenarios during the training phase. Our system can be modeled by a process where each node represents a state that takes all of the patient as given in, and the decision to move to another state as output.

To bring the device to the best of reality, innovative methods to model the surgical procedure are necessary, but also medical knowledge, mastery of surgical procedures and non-technical aspects such as cognitive skills. Such a project requires a long conceptual modeling effort. For surgical procedures, it is to design an environment that will allow training surgeons to learn and repeat the operation scenario.

The system supervises in real time by sensors surgical gestures of the users and it triggers an alert when an anomaly, detected a dysfunction, he must then proposed the following action in a very short lapse of time to avoid an expected risk.

To anchor such a simulator in the real, our system is based on real cases of transactions, they detail point by point description by using pertinent methods to define a common and shareable vocabulary that ultimately could become a standard.

The next step is to integrate the variability of possible scenarios in the simulator because during an operation, things do not always go the same way. It is on this issue that the team operates with a method that will take into account the paths that have been observed once, but also unobserved which is contradicted neither by logic nor by observations.

IV. MANAGING RISK

The operating room is a complex system, the greater the complexity, the greater the risk of default and non-detection is important if the system is not under control. This fragile system

is likely to generate multiple faults occurring side effects of nature and severity variables.

It is also a system in which risk prevention logic makes sense because a large part of adverse events that occur are avoidable.

It is important to note that risk management is not securing each step but the whole process because it is this that is fallible.

It is a skilled and replacement surgery, programmed, with anesthesia, based on an organizational, therapeutic and architectural concept centered on the patient.

So this practice implies the existence of a proper structural framework centered around the concepts of quality and safety.

One of the major difficulties in decision making, especially in medicine and public health, comes from the uncertainty associated with the information (knowledge, observations) that come into play in the decision process.

A. The uncertainty intervenes at various levels:

- **On knowledge:** Some knowledge of statistical (frequency of illnesses or signs) and are associated by nature a risk of error, but other knowledge is incomplete, default exploration or conceptualization failure.
- **The facts:** the description of the present state is never perfect, either by lack of resources or time (emergency) or by measurement error or misinterpretation of a symptom, a sign or a result.
- **The level of language:** some terms used are inherently ambiguous and uncertain, especially in the context of a medical consultation.

V. THE SURGICAL SIMULATION:

Simulation is an active and innovative teaching method, based on experiential learning and reflective practice. Simulation programs are developed in line with the recommendations of the professional structures of each discipline.

The term health simulation is the use of a material (such as a model or a procedural simulator), of virtual reality or a standardized patient, for reproducing care situations or environments, to teach diagnostic procedures and therapeutic and allow to repeat processes, clinical situations or decisions by a health professional or team of professionals. It is a continuing professional development method.

The simulation in our case corresponds to the use of a 3D software application with sensors, virtual reality, for reproducing care situations or environments, to teach diagnostic and therapeutic procedures and enable repeating processes, clinical situations or decisions by learners.

1. Form to procedures, to gestures or care situations;

2. Acquire and update knowledge and technical and soft skills (teamwork, communication between professionals, etc.); Analyze their professional practice by wearing a new look at yourself during the debriefing;

3. Address the situations "at risk for the patient" and to improve the ability to cope by participating in scenarios that can be rehearsals;

4. Reconstitute adverse events, understand during the debriefing and implement care safety improvement actions.

VI. VIRTUAL REALITY

Virtual reality is a scientific and technical field, it operates computing and behavioral interfaces to simulate a virtual world behavior of 3D entities that interact in real time with each other and with one or more users pseudo-natural immersion via sensorimotor channels. It helps to understand complex situations, or explore concepts illustrated more concretely by computer modeled. These applications are interactive and allow for example to understand how equipment can be used to train to make clinical decisions for a virtual patient based on the adjustment of different variables, but only through the screen the computer.

Augmented reality refers to computer systems that make it possible to overlay a virtual 3D or 2D model to the perception that an individual is naturally of reality and in real time. It refers to the various methods to embed realistic virtual objects in an image sequence. It applies both visual perception (virtual image superimposed on real images) as proprioceptive perceptions such as touch or hearing perception.

VII. 3D ENVIRONMENT AND SERIOUS GAMES

The 3D environment resembles in its realism environments best performing video games, although the cost of creating virtual realistic environments is very high. These techniques do not present limits theory in the different situations that can create and allow a full immersion in the staged situation.

Serious games are applications developed using advanced gaming technologies, using the same design approaches and expertise that the classic game (3D real-time simulation of objects, people, environments...) but beyond the single dimension of entertainment. They combine serious intent, educational kind, informative, communicative, or workout with fun spring. They are somehow a useful variation of video game serving professionals.

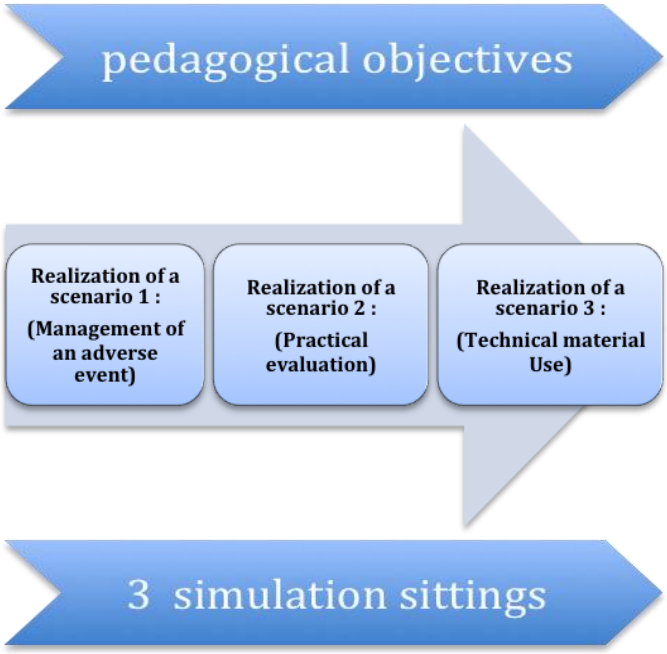

Figure 3. Pedagogical objectives

VIII. LEARNING TO SURGICAL INTERVENTION

The formation of surgeons has a long practice of learning surgical intervention, in addition to training in anatomy and procedures. This training action is done on animals, cadavers or experiencing companionship. During the fellowship, the internal practical gestures under the control and responsibility of a more experienced surgeon. Training surgeon gesture raises economic difficulties, ethical, educational and practical; there would be a clear benefit to find alternative or complementary solutions to learning surgery, allowing the formation gesture without using animals or cadavers.

Recent advances in virtual reality technologies have also enabled the development of new interactive surgical simulation devices. By reproducing the visual sensations and gestures of a surgeon, they allow learning the gesture by immersion in virtual environments. Among others, specific devices suitable for the very special interface of minimally invasive surgery exist, as illustrated by some commercial devices.

Virtual reality then seems to be an interesting basis for developing interactive and immersive applications to increase the effectiveness of learning.

IX. BAYESIAN NETWORKS

Bayesian networks, initiated by Judea Pearl dice the 80 are graphical models that represent probabilistic relationships between a set of variables. It is therefore a probabilistic approach, or the value of each variable is induced - or not - by the values of other related variables.

The essential idea is therefore to calculate the probability of a given event based on the likelihood of other previously observed events. This is inferred from the effects of causes.

A Bayesian network is based on this: An event A occurs. What is the probability that this is the cause that has produced Mi?

$$P(Mi|A) = \square(\square|\square\square) * \square(\square\square) / \square(\square)$$

With P (Mi|A): Posterior probability

And P (A): constant (for each Mi)

The generalized Bayes theorem gives:

$$P(A1 \ldots An) = P(A1)P(A2|A1)P(A3|A1, A2) \ldots P(An|A1 \ldots An-1)$$

This is theorem, which is implemented in software Bayesian networks.

A Bayesian network B = (G;) is therefore defined by: the set of observable random variables X = □ □□

- G = (X;E), directed acyclic graph (DAG), and each node is associated with a variable X.
- □ = □□ = (□□|(□□)) all probability distributions of each node Xi, which has conditionally its immediate parent in the graph G.

The graph of a Bayesian network and can present a visually the relationships (dependencies and independence) between system variables. The probability distributions are used to enrich the graphic structure by quantification of these relationships. The probabilities in a Bayesian network can represent the uncertain aspect that connects the variables.

The inference in a Bayesian network is a calculation of conditional probabilities: it consists of an update of the probabilities of unobserved variables after watching the values of a number of other variables.

X. THE MODELING PROCESS

Our research process design for learning in surgery, particularly outpatient surgery, with a view to reducing the gap between theoretical and practical aspects of this training.

We presented the methodology of analysis and implementation of the educational model of Intelligent System incorporating a model of domain knowledge representation, a diagnostic model of learner knowledge and didactic model of decision-making and feedback teaching. We describe in this section the architecture of learning and the operation of the simulation environment system.

The proposed modeling process provides templates (knowledge model, action models, and model results) whose evaluation is used to size the system and get its performance. In this context fits this research work, which is to develop an intelligent system of decision support based on an expert system and the establishment of a process approach in the context of a System Modernization Project Information helps make its information more efficient, more responsive to business needs to be better accepted by the medical community.

This technological evolution of medicine revolves around two main aspects that are using medical decision through medical expertise throughout the chain of care, and training of health personnel, thanks a greatly increased intercommunication between the various players in the medical field.

CONCLUSION

The focus here is particularly to the problem of minimizing the uncertainty in the medical field. It is therefore to introduce intelligence in medical decision-making systems to maximize their certainties, their flexibility and robustness, and increase their ability to aid prognosis, diagnosis and decision therapy in outpatient surgery.

In this section we worked on Bayesian networks are excellent modeling tools of uncertainty through their clear graphical representation and conditional probability distributions defined on this graph and the ability to manage multiple heterogeneous data sources and also the direct or indirect causal dependencies between several variables. Indeed, the interest of the problem of an educational system based managed using the medical decision and especially in outpatient surgeries is the one of uncertainty and reasoning under uncertainty. Information is uncertain, unreliable and noisy. But the models are as uncertain and not always adequate. However, IT must provide comprehensive scenarios or at least a sufficiently precise indication for the trainee can make the right decision.

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