INTELLIGENT DECISION SUPPORT IN INTENSIVE CARE – TOWARDS TECHNOLOGY ACCEPTANCE

Filipe Portela[1], Manuel Filipe Santos[1], José Machado[2], António Abelha[2], José Neves[2], Álvaro Silva[3], Fernando Rua[3]

[1]Algoritmi Center, University of Minho, Campus de Azurém, Guimarães, Portugal
E-mail: {cfp, mfs}@dsi.uminho.pt
[2]CCTC, University of Minho, Braga, Portugal
E-mail: {jmac, abelha, jneves}@di.uminho.pt
[3]Serviço de Cuidados Intensivos, Centro Hospitalar do Porto, Hospital Santo António, Porto, Portugal
moreirasilva@clix.pt , fernandorua.sci@hgsa.min-saude.pt

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ABSTRACT

Decision support technology acceptance is a critical factor in the success of the adoption this type of systems by the users. INTCARE is an intelligent decision support system for intensive care medicine. The main purpose of this system is to help the doctors and nurses making decisions more proactively based on the prediction of the organ failure and the outcome of the patients. To assure the adoption of INTCARE by the doctors and by the nurses, several requirements had taken into account: process dematerialization (information is now in electronic format); interoperability among the systems (the AIDA platform was used to interoperate with other information systems); on-line data acquisition and real-time processing (a set of software agents has been developed to accomplish these tasks).
A technology acceptance methodology has been followed in the Intensive Care Unit (ICU) of Centro Hospitalar do Porto in order to assure the most perfect alignment between the functional and technical characteristics of INTCARE and the user expectations. Results showed that the ICU staff is permeable to the system. In general more than 90 % of the answers are scored with 4 or 5 points which gives a good motivation to continue the work.

INTRODUCTION

The INTCare project, started in 2009 with the purpose to develop an Intelligent Decision Support system to predict the organ failure and patient outcome in intensive care medicine. Early results obtained with the data from EURICOS project, in an offline learning approach, motivated further developments (Silva, Cortez, Santos, Gomes, & Neves, 2008). However, a huge challenge arisen to adapt the system to a real-time and online environment. The main challenge was related to the distributed nature of the information sources and to the paper based processes still in use in the Intensive Care Unit (ICU). In order to overcome these issues some requirements were defined.
The requirements defined to turn INTCare more suitable for the ICU environment, may be summarized as:

1. To implement an online data acquisition component;
2. To make available the lab results data in open format;
3. Allow for open access to prescriptions, interventions and therapeutics attitudes;
4. To dematerialize the nursing record;
5. To integrate the main systems used in ICU in a single platform;

To achieve these objectives a new system and platform was developed. This platform was based in a concept of having a multi data source in one application with the goal to reduce the time the doctors or nurses spent on documentation and consequently increase the time of patient care (Häyrinen, Saranto, & Nykänen, 2008; Vandijck, Labeau, & Blot, 2008). This new solution can integrate all data sources that are essential to work in the best interest of the patients. Like Brailer (Brailer, 2005) said without interoperability, Electronic Medical Record (EMR) adoption will further strengthen the information silos that exist in today's paper-based medical files, resulting in even greater proprietary control over health information and, with it, control over patients themselves. In addition, providing patient data electronically, online and in real-time, the information will be available anywhere and anytime.
Finally, decision support technologies like the INTCare system should be more framed in the user environment, assuring the user acceptance (Chooprayoon & Fung, 2010).
The Technology Acceptance Model (TAM) (Venkatesh & Bala, 2008; Venkatesh & Davis, 2000) is been applied to assure the adoption of INTCare by the ICU users (doctors and nurses). This paper will present the first questionnaires done after conclude the test phase, with the objective to understand the importance of the system to ICU and their professionals. The results obtained encourage the continuation the development and optimization of the solution and also to deep evaluation of all features, using TAM (Chooprayoon & Fung, 2010).
The following sections of the paper will be dedicated to: present the background knowledge and related work in section 2; section 3 introduces the departure point of the INTCare system; section 4 is focused in the improvements implemented; section 5 is dedicated to the electronic nursing record, an important component in the prosecution of the objectives; section 6 presents the results obtained so far in terms of the degree of interoperability, dematerialization of processes and the technology acceptance; and, finally, section 7 concludes the paper criticizing and points future directions.

BACKGROUND AND RELATED WORK

INTCare

INTCare (Gago et al., 2006) is a research project which has as main goal to develop an Intelligent Decision Support System (IDSS) that can, in real-time and in an online

learning mode (Portela et al., 2010), predict the outcome and organ system failure in a pervasive approach (Portela, Santos, Silva, Machado, & Abelha, 2011). INTCare is in use in the Intensive Care Unit (ICU) of the Centro Hospitalar do Porto, Porto, Portugal. The main motivation to the developing of a new information system were the number of data in paper and information silos, which exist in ICU and, difficulties to obtain data to INTCare Data Mining models. These data were defined based in the results obtained in the past (Silva, et al., 2008). To the INTCare a set of agents were developed with aim to automatize some important tasks, avoiding the manual effort. The use of intelligent agents is fundamental to an implementation of a real-time and online information system. The agents are integrated in a Multi-Agent System (MAS), they communicate with each other and work together towards common goals, with a degree of reactivity and / or reasoning (Wooldridge, 1999).

Intensive Care

Normally, to Intensive Care Units (ICU) go patients in seriously weak conditions, where the organ failure is / can be a reality. This environment is considered critical because have some complex health care situations and the risk life is obvious. ICU is a data-rich environment (Lapinsky, Holt, Hallett, Abdolell, & Adhikari, 2008) and every hour a great amount of clinical data are generated and stored in paper format. This process difficult the data dissemination and data consult. Typically the information used is provided from a lot of different sources that can be electronic or manual. Other problem is the delay of data, i.e., the time difference between data acquisition and data availability. At the beginning in this ICU the data was collected in offline and in an irregularly mode making the analysis of patient data and the search of past information a very hard and time-consuming work. The existing information systems were only used for information consultation and not to register patient data. For instance, the bedside monitors were only used to visualize the patient Vital Signs (VS), these weren't stored in a database or used by the information systems (Filipe Portela, Manuel Filipe Santos, et al., 2011). To develop a pervasive health care (PHC) system to ICU is important to have present the general requirements defined by Varshney(Varshney, 2007).

AIDA

AIDA(Duarte, Portela, Santos, António, & José, 2011) is an Agency for Integration, diffusion and Archive of Medical Information. This platform is implemented in CHP and according Abelha (Abelha, Machado, Alves, & Neves, 2004), provides intelligent electronic workers, here called pro-active agents, and is in charge of tasks such as communicating with the heterogeneous systems, sending and receiving information, managing and saving the information and answering to information requests, with the necessary resources to their correct and in time accomplishment. Although AIDA was implemented in ICU, still exists a set of clinical applications which can't communicate between them (e.g. platform of nurses and medics). In these cases, normally, the information will be lost in the time. In other case, is too difficult accede to data in a quick and efficient way. The introduction of a new information system which, can integrate, using systems interoperability, all ICU data sources, can be the best solution.

Technology Acceptance Model

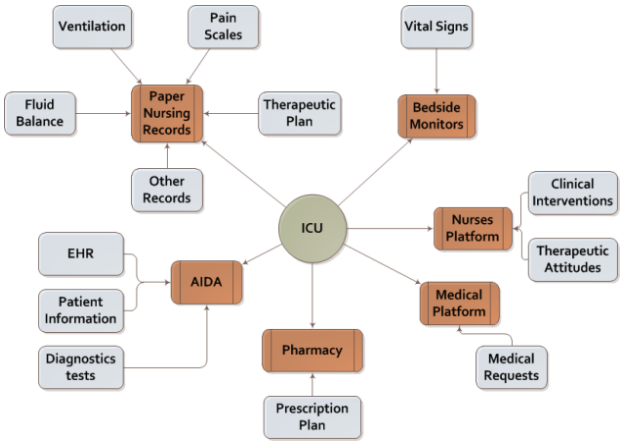
To understand if some technology is or not adequate to the environment and if the users are happy with the solution, is extremely necessary evaluate the success of the application. One of the models most used in this area is TAM. Since it development, in 1989, it suffered a set of improvements and changes of content. "TAM is adapted from the Theory of Reasoned Action (TRA) model which describes human behaviours in a specific situation" (Fishbein & Ajzen, 1975). The main purpose of TAM is to present an approach to study the effects of external variables towards people's internal beliefs, attitudes, and intentions (Chooprayoon & Fung, 2010), understanding, the ease of use (PEOU) and usefulness (PU) of technology. The goals of TAM can be achieved, for example, by using methodologies based in questionnaires. TAM (Venkatesh & Bala, 2008; Venkatesh & Davis, 2000) was the guide of the questions done and will be used, in the future, to do a most deep study of the application.

GLOBAL OVERVIEW

To develop INTCare a deep study, about the environment, were done. The necessities of innovation and features that need to be implemented were defined (Filipe Portela, Manuel Filipe Santos, et al., 2011). In this context was possible verify that:

- Vital signs monitors were used to visualize the values;
- The lab results were available in a closed format;
- The prescriptions were registered in paper by the nurses;
- The patient data, ventilation, fluid balance and medical scores are registered and calculated manuallyand in paper;
- Some registries weren't done regularly;
- Many sources containing vital data were distributed by distinct silos.

Figures 1 depicts an overview of the data sources that daily are used by nurses and doctors in ICU. Besides the high number of data sources and the necessity to use different platforms to consult / store the information, the nursing record were still made in paper and can't be used by other platforms. Orange shapes represent the data sources, associated to the information that normally are requested. The other shapes represent this information. For example, in case of AIDA, ICU normally request information about Electronic Health Record (EHR), patient and diagnosis tests.



Figures 1: ICU Data Sources

IMPROVEMENTS INTRODUCED

In order to resolve the limitations reported before, a set of modifications were introduced. These improvements will be briefly explained in the next sub-sections.

Data acquisition system

The first concern was about the vital signs, the possibility of use the values that were in patient bedside monitor and store them into a database. To resolve this, a gateway was implemented; it is connected to the vital signs monitors, reads the patient information and stores it on a database through the data acquisition agent. Due to the high number of data provided by the gateway, the interval of time defined for sampling was 8 minutes. After the process is concluded the data will be displayed in the ENR platform. During this process some important problems were resolved. The problem of patient identification and data out of range or badly collected were overcome. In both cases, the introduction of new tasks to the agent was the solution. The agent can verified who patient are in the bed (admitted in EHR) and can compare the values collected with the max and min normally allowed in the ICU (F. Portela et al., 2011).
After all values are correctly identified and validated, they will be, on moment, available in the Electronic Nursing Record platform (online). Now, instead be necessary see the monitors to consult the patient vital signs and then store them manually in a paper, the ICU professional only needs to confirm those values in the platform.

Lab results

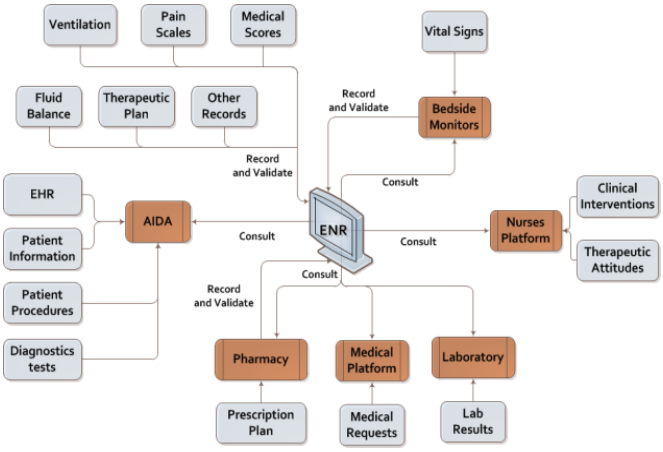
Second, and considering that laboratory are an important source for ICU, an effort were made to have the lab results in an open format, making the results available for ICU immediately after the patient exams be concluded. This change gives the possibility to have the results in a comparative format during the patient stay in ICU.
The Lab Results are not under the nurse's control in the ICU, because they are ordered by the doctors and executed by the labs (Filipe Portela et al., 2011). Normally these analyses are done 1 to 3 times-a-day, however they can be done more times. Those analyses have different types, are executed by different services and at different hours. The integration and grouping of obtained results are done by ENR. Lab Results agent is responsible to receive and store the results in a table. All data acquired are available to be consulted in the ENR. Laboratory releases the results of fowling services: Microbiology, Haematology, Urgency exams, Serology, Immunology, Clinical Chemistry, Respiratory gas measurement

Open access to prescriptions

In this step, the objective was obtaining a partial access to data provided from the pharmaceutical information system. After some dealing was possible have an access to patient prescriptions. These prescription, were totally controlled by pharmacy, and always someone needed to consult the patient therapeutic plan had to open a too slow platform. The interaction between the pharmaceutical system and ENR is made by an agent. Periodically (10 in 10 minutes), the ENR agent sends a request to the pharmacy drugs system, and then, the data requested will be sent into a table. After the data is store, a pre-processing agent runs to prepare all data to ENR and stores them. This process involves a high number of processing tasks in real-time.

ELECTRONIC NURSING RECORD

Electronic Nursing Record (ENR) is a platform that was developed with the objective to receive all medical data and put it available to doctors and nurses in an hourly-based mode where all operations can be registered through a simple interface. The information used in the ICU is provided by different platforms. Figures 2 represents well the interoperability between ENR and the other data sources. Opposing the fig 1 is possible verify that all data sources converge to the same platform: ENR. Now, aren't the ICU professionals who request the data but the platform which is always searching from new data from other data sources. The implementation of ENR gives also the opportunity to have more data available. Data which were not recorded electronically like is the case of ventilation, pain scales, medical scores, fluid balance, therapeutic plan, and others.
The other data sources that previously were accessed through a set of distinct application are now available in the ENR. The data provided from the platforms of nurses and doctors are integrated in ENR. The data provided by the laboratory results are now in an open format and they are displayed in a grid format organized by day and exams. The prescription plan provided by the pharmacy is divided by drugs, hour and dosages and it is put in a table with 25 columns one with the name of drug and the others with the hours (24). All the prescriptions data are displayed in a grid. Finally, the platform of AIDA and EHR also are integrated in the ENR. ENR has a special tab with the AIDA. The user of ENR can consult all the data provided by all the platforms however, only can registry and validate the data inserted manually and provided by the bedside monitors and the pharmacy.
The digital nature of the ENR turns the data contained in it searchable and retrievable (Filipe Portela, Pedro Gago, et al., 2011).



Figures 2 ENR interoperability overview

This platform is touch and web-based and is compoed by different screens, grouping the data by the information provenance. Data about vital-signs and prescriptions will be available in the same grid. This grid has one column for the variable identification, 24 for each hour (1-24) and two more

which is used by fluid balance to store the input and output values. In case of vital signs only the first value correctly validated of the hour will be inserted. The data obtained from prescription were extremely and carefully prepared and distributed, in a grid, by hour, dosage, category and type. The data provided from Lab Results has an own screen. This screen also is composed by a grid which facilitates the data consulting. The results collected were grouped by day, hour and type. The professionals can, in an easy and quick way, analyses the patient results today and for examples two days ago. For all cases, always some new result were available the platform will refresh and put them in the correct place.

RESULTS

After the new features were incorporated in the INTCare system, the benefits of them for ICU were notorious. The first benefit is related to the number of different information platforms supporting the ICU processes. The ICU professionals normally had to access to six different platforms – Bedside Monitors (BM), Nursing Record Paper Based (NRPB), AIDA, Medical Platform (Mplat), Nurses Platform (Nplat) and Pharmacy, to consult essential information to decision / job. Table 1 presents the kind of pieces of information normally consulted from the six different platforms. All of them are now available in a single platform (ENR).

Table 1: ICU Information Platforms

Information	***Before***	***Now***
Ventilation	NRPB	ENR
Pain Scales		
Fluid Balance		
Therapeutic Plan		
Other Records		
EHR	AIDA	
Patient Information		
Diagnostics tests		
Vital Signs	BM	
Prescription Plan	Pharmacy	
Medical Requests	Mplat	
Clinical Interventions	Nplat	
Therapeutic Attitudes	-	
Lab Results	-	
Patient Procedures	-	
Medical Scores	-	

Another benefit (**Error! Reference source not found.**) obtained was the number of pieces of information available electronically (E), online and in real-time (ORT). The initial situation (50% of ORT) evolved to a complete ORT approach.

Table 2: Information type available in ICU (comparison)

Information Type	***Before***		***Now***	
	Source	ORT	Source	ORT
Ventilation	**P**	**X**	**E**	√
Pain Scales	**P**	**X**	**E**	√
Fluid Balance	**P**	**X**	**E**	√
Therapeutic Plan	**P**	**X**	**E**	√
Other Records	**P**	**X**	**E**	√
HER	**E**	√	**E**	√
Patient Information	**E**	√	**E**	√
Diagnostics tests	**E**	√	**E**	√
Vital Signs	**P**	**X**	**E**	√
Prescription Plan	**P / E**	√	**E**	√
Medical Requests	**E**	√	**E**	√
Clinical Interventions	**E**	√	**E**	√
Therapeutic Attitudes	**E**	√	**E**	√
Lab Results	**P**	**X**	**E**	√
Patient Procedures	**P / E**	√	**E**	√
Medical Scores	**P**	**X**	**E**	√

The benefits obtained with the changes in the environment and in the information system gives the possibility to create a pervasive intelligent decision support system – INTCare. INTCare system provide three groups of information which can support the decision making process in the different parts of them. Using the streamed data (Gama & Gaber, 2007), i.e., data collected automatically and in real-time, the ENR, AIDA (Abelha et al., 2003), and the hospital interoperability system (Brailer, 2005; Häyrinen, et al., 2008) , is possible processing the data automatically and using online learning in order to obtain:

a) ICU Scores;
b) Critical Events;
c) Predict organ failure and patient outcome.

Improvements and System assessment

All of the improvements were assessed in terms of their functionality and usability. A restrict and specialized number of users were asked. During this time two doctor and six nurses (~15 % of ICU professionals) explored the platform and answered the questionnaires. All of them were familiarized with the ICU Clinical systems, being a daily user of them. The use of a reduced number of professionals was a strategy, because during the test phase of the system is too important not demotivate the professionals with some possible failures. This objective, is easily achieved with a performing of lot of test near the ICU professionals which are more trained for direct patient care and understand the risks / complexity of this type of systems.

The users answered to a questionnaire in order to assess the technology. With the objective to give a global idea about the usefulness and ease of use of the system in superficial way, an easy and quick questionnaire was done.

To the questionnaire, a metric evaluation scale was defined:

1) Does not meet / in complete disagreement (<20% of cases),
2) Meets some / disagree (20 -40%),
3) Meets / agreement (40-60%),
4) Very satisfied / very agreement (60-80%),
5) Fully meet / fully agree (> 80%))

The questions were grouped in two groups:

1 Functional characteristics The registration system allows efficient information?

1.2 The system allows for an efficient consulting of information for nursing decision support?

1.3 The system allows for an efficient consulting of information for medical decision support?

1.4 The system enhances the proactive performance of the professionals?

2 Technical characteristics The system responds with an appropriate quality and speed to the needs?

2.2 The access to the information, in terms of speed and availability, correspond to the needs?

2.3 The access to the system is easy and secure?

2.4 The system interoperability, with other systems (e.g. EHR), suits the needs?

2.5 The touch interface at the bed side allows for an easy operation of the system?

The Table 3 presents the results obtained, in terms of the percentage of answers for each question and each score level.

Table 3: Questionnaire results

Query	1	2	3	4	5
Functional characteristics					
1.1	0,00	0,00	16,67	0,00	83,33
1.2	0,00	0,00	0,00	16,67	83,33
1.3	0,00	0,00	0,00	0,00	100,00
1.4	0,00	0,00	0,00	83,33	16,67
Technical characteristics					
2.1	0,00	0,00	0,00	100,00	0,00
2.2	0,00	0,00	0,00	66,67	33,33
2.3	0,00	0,00	0,00	33,33	66,67
2.4	0,00	0,00	0,00	50,00	50,00
2.5	0,00	0,00	16,67	0,00	83,33

The results obtained were treated and despite according the responsibility of each inquired. For example in case of the nurses only question about the nursing care were considered as answer. In a first approach, is possible to observe that the results obtained are good and the ICU professionals are very comfortable with the new system. In general, more than 90 % of the answers are scored with 4 or 5 points which gives a good motivation to continue the work, improving this system. Only two questions were answered with 3 points in a five-scale point. These questions are related with a functional aspect and a technical aspect.

At level of functional aspect the question which obtained 3 points was concerned with the registration system. This result happens due the possibility of user with the haste records wrong data. This is a valid answer because the clinical care is always the first concern by the nurses.

In the technical aspect, the fact of touch-screen being a novelty and the users are accustomed with records in paper it is difficult to some users at first contact have a quick understanding of the system and their benefits.

Resuming, it is possible observe that this system allow an efficient and quick access to the essential data which support the clinical decision process.

Now, and after this test phase finish a set of new questionnaires will be done for each TAM area and most people will be added to the process.

CONCLUSIONS AND FUTURE WORK

The success of decision support systems depends on the technology acceptance by the users. In the intensive care area this is of the most importance and is very difficult to be achieved. Further than contribute to accurate decision models, a set of specific requirements was considered:

- A complete dematerializations of the processes;
- An online data acquisition and processing;
- A real-time decision support;
- Access to data in open-format in order to evaluate the values in terms of scores and alarms;
- Interoperate with the systems and equipment present in the ICU environment.

This paper presented all the improvements introduced in INTCare system towards to the user's acceptance fulfilling the requirements enunciated. Tables 1 and 2 resume the benefits obtained in terms of the degree of interoperability and the dematerialization attained.

The study carried out on the technology acceptance (Table 3) corroborated the options made during the development of INTCare system. The system is now in use in the ICU of Centro Hospitalar do Porto, Porto, Portugal.

In the future, an analysis of effective gains with the reduction of time recording and patient caring will be done and the impact on ICU Cost/Quality (Cassi, 2009). In parallel all features of the system will be carefully evaluated by the ICU professionals. The system will be in a continuous development and optimization according the answers obtained and recitals done.

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REFERENCES

Abelha, A., Machado, J., Alves, V., & Neves, J. (2004). Data warehousing through multi-agent systems in the medical arena.

Abelha, A., Machado, M., Santos, M., Sollari, A., Rua, F., Paiva, M., et al. (2003). Agency for Archive, Integration and Diffusion of Medical Information. *Proceeding of AIA*.

Brailer, D. J. (2005). Interoperability: the key to the future health care system. *Health Affairs-Millwood Va Then Bethesda MA-*, *24*, 5.

Cassi, A. (2009). Despite Wide Adoption, Little Evidence of eICU Impact on Intensive Care Cost/Quality. *Health Affairs*.

Chooprayoon, V., & Fung, C. C. (2010). TECTAM: An Approach to Study Technology Acceptance Model (TAM) in Gaining Knowledge on the Adoption and Use of E-Commerce/E-Business Technology among Small and Medium Enterprises in Thailand.

Duarte, J., Portela, F., Santos, M. F., António, A., & José, M. (2011). *Electronic Health Record in Dermatology Service.* Paper presented at the *HCist 2011* – International Workshop on Health and Social Care Information Systems and Technologies, Algarve, Portugal.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behaviour: An introduction to theory and research*: Addison-Wesley.

Gago, P., Santos, M. F., Silva, Á., Cortez, P., Neves, J., & Gomes, L. (2006). INTCare: a knowledge discovery based intelligent

decision support system for intensive care medicine. *Journal of Decision Systems*.
Gama, J., & Gaber, M. M. (2007). *Learning from data streams: processing techniques in sensor networks*: Springer-Verlag New York Inc.
Häyrinen, K., Saranto, K., & Nykänen, P. (2008). Definition, structure, content, use and impacts of electronic health records: A review of the research literature. *International Journal of Medical Informatics, 77*(5), 291-304.
Lapinsky, S., Holt, D., Hallett, D., Abdolell, M., & Adhikari, N. (2008). Survey of information technology in Intensive care units in Ontario, Canada. *BMC medical informatics and decision making, 8*(1), 5.
Portela, F., Gago, P., Santos, M. F., Silva, A., Rua, F., Machado, J., et al. (2011). *Knowledge Discovery for Pervasive and Real-Time Intelligent Decision Support in Intensive Care Medicine*. Paper presented at the *KMIS* 2011- International Conference on Knowledge Management and Information Sharing.
Portela, F., Santos, M., Vilas-Boas, M., Rua, F., Silva, Á., & Neves, J. (2010). *Real-time Intelligent decision support in intensive medicine*. Paper presented at the *KMIS* 2010- International Conference on Knowledge Management and Information Sharing.
Portela, F., Santos, M. F., Gago, P., Silva, Á., Rua, F., Abelha, A., et al. (2011). Enabling real-time intelligent decision support in intensive care.
Portela, F., Santos, M. F., Silva, Á., Machado, J., & Abelha, A. (2011). *Enabling a Pervasive approach for Intelligent Decision Support in Critical Health Care*. Paper presented at the *HCist 2011* – International Workshop on Health and Social Care Information Systems and Technologies.
Santos, M. F., Portela, F., Vilas-Boas, M., Machado, J., Abelha, A., Neves, J. (2009). *Information Architecture for Intelligent Decision Support in Intensive Medicine*. Paper presented at the 8th WSEAS International Conference on Applied Computer &Amp; Applied Computational Science (ACACOS '09).
Silva, Á., Cortez, P., Santos, M. F., Gomes, L., & Neves, J. (2008). Rating organ failure via adverse events using data mining in the intensive care unit. *Artificial Intelligence in Medicine, 43*(3), 179-193.
Vandijck, D. M., Labeau, S. O., & Blot, S. I. (2008). Level of knowledge articulated by intensive care nurses and clinical decision-making. *Intensive and Critical Care Nursing, 24*(1), 6-7.
Varshney, U. (2007). Pervasive healthcare and wireless health monitoring. *Mobile Networks and Applications, 12*(2-3), 113-127.
Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences, 39*(2), 273-315.
Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management science*, 186-204.
Wooldridge, M. (1999). Intelligent agents *Multiagent systems: a modern approach to distributed artificial intelligence* (pp. 27-77): MIT Press.

AUTHOR'S BIOGRAPHY

Filipe Portela is a PhD Student in Information Systems in Minho University. He is inserted in the R&D Centre ALGORITMI and is developing his research work in the topic "Pervasive Intelligent Decision Support in the Critical Health Care". This research was started with the INTCare research project, has been doing in cooperation with the ICU of CHP and already has some important publication in Intelligent System, Pervasive Environment, Intensive Medicine, Data Mining Knowledge Discovery and Decision Support areas.

Manuel Filipe Santos holds a PhD in Computer Science – Artificial Intelligence. Actually he is associate professor in the department of information systems, school of engineering, University of Minho, Portugal. He is the Investigator Responsible in research projects (grid data mining and intelligent decision support systems for intensive care). He is the head of the Intelligent Data Systems group in the R&D Centre Algoritmi. He has more than 60 publications in conference proceedings, chapter books and journals. His main interests are: Knowledge Discovery from Databases and Data Mining, Intelligent Decision Support Systems, Machine Learning.

Álvaro Silva, holds a PhD and is guest professor in Abel Salazar Biomedical Sciences Institute and works as a Doctor in the Intensive Care Unit of Centro Hospital do Porto (CHP) in Portugal, where he has been doing research in the intensive medicine and data mining area. He belongs to the INTCare project team and is responsible by the connection between the Information System and Intensive Medicine area. In the last year, his knowledge and work contributed for publishing some important papers about Intelligent System in ICU.

Fernando Rua is a graduate doctor in Intensive Medicine. He is the Chief Officer of Intensive Care Unit of CHP in Portugal. He also develops research related with information systems and intensive medicine. He belongs to the INTCare project team and is responsible by the connection between the Information System and Intensive Medicine area. In the last year, his knowledge and work contributed for publishing some important papers about Intelligent System in ICU.

António Abelha is an Auxiliary Professor at University of Minho, Department of Informatics, in Braga, Portugal and **José Machado** is an Associate Professor with Habilitation in the same department. They got their PhD in Informatics, respectively in 2004 and 2002, and are researchers of Computer Science and Technology Center (in Portuguese CCTC). Their research interests span the domain of Electronic Health Records, Interoperability, Databases and Artificial Intelligence.

José Neves is full professor at the Department of Informatics of the University of Minho. He got a PhD in Computer Science in 1984 in Edinburgh and has published more than hundred papers in book chapters, conference proceedings and journals.