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Real Time Local Model Predictive Control for Reactive Navigation with Wheeled Mobile Robots

Lluís Pacheco and Ningsu Luo
Institute of Informatics and Applications
University of Girona
Girona, Spain
lluispa@eia.udg.edu, ningsu@eia.udg.edu

***Abstract*—This paper presents the use of model predictive control techniques applied to a differential driven WMR (wheeled mobile robot) for local navigation in dynamic environments. Local trajectory-tracking is a relevant idea of this work; hence when dynamic environments or obstacle avoidance policies are considered the navigation path planning should be flexible and constrained to the robot neighborhood. In this sense, a set of dynamic models obtained from the experimental robot system identification are used to predict the horizon of available coordinates. The simulation results are used to orient further experimental results. Moreover, experimental cost function tuning is used to improve the control system performance by testing a set of different trajectories. The benefits of the implementation presented are accuracy, low computational cost, and simplicity.**

Keywords-autonomous mobile robots; model based control; on-line local predictive control; reactive navigation;

I. INTRODUCTION

This paper presents control techniques based on MPC (model predictive control) applied to a differential driven WMR (wheeled mobile robot). Moreover, other important aspects as the local on-robot perception and navigation issues are considered as important constraints in order to accomplish the different missions. The control strategies, applied to WMR, should fulfill safety rules as well as achieve the final desired configuration. Scientific community has developed several studies in this field. The dynamic window approach is based on the dynamic constraints of WMR and uses the available robot speeds for planning the avoidance of obstacle collisions, safety stops and goal achievements [1]. In the work of Rimon it is presented the methodologies for the exact motion planning and control, based on the artificial potential fields where the complete information about the free space and goal is encoded [2]. However, under dynamic environments the global solution becomes unfeasible for the majority of applications where the scenario should be considered as partially unknown due to the lack of global sensors or the existence of dynamic obstacles. Hence, some approaches on mobile robots propose the use of potential fields, which satisfy the stability in a Lyapunov sense, in a short prediction horizon that allows dealing with obstacle avoidance policies as well as final goal approaches [3]. Thus, convergence to goal and reactive behavior can be done by casting the two objectives in a MPC and CLF (control Lyapunov function) framework [4]. Trajectory tracking by using predictive control techniques is a well known topic [5]. The majority of the research developed by using MPC techniques and its application to WMR is based on the fact that the reference trajectory is known beforehand [6]. The MPC applicability for agricultural vehicle guidance has been depicted in [7], where kinematics models and different on-field fixed trajectories were tested. However, due to the unknown environment uncertainties, short prediction horizons are proposed in this paper.

The main contribution presented in this research consists in analyzing the performance of MPC techniques for trajectory-tracking when short prediction horizons are used. Therefore, LMPC (Local Model Predictive Control) is developed. The use of such techniques can deal with dynamic environment uncertainties. Moreover, the use of constrained fields of perception dealt with on-robot sensors avoids the need of global sensors. In this context, the trajectory knowledge is provided at each perception steep. Thus, the local trajectory-tracking proposal consists of one single achievable coordinate that is dynamically updated by the sensor system. The benefits of the methodology presented are the accuracy, simplicity and low computation cost. The navigation strategy is oriented to obtain goal approaching trajectories while obstacle avoidance is attained. Moreover, the techniques for obtaining the dynamic models of the WMR as well as the cost function performance for tracking the local trajectories are depicted. Therefore, the methodology presented can be employed for WMR local navigation under dynamic environments when on-robot sensors such as laser range finders, sonar or machine vision systems are used. The paper is organized as follows. The Section II presents the robot kinematical system used for performing the trajectory tracking as well as the experimental methodology used to obtain the different dynamic models. The Section III introduces the MPC formulation for trajectory tracking as well as the preliminary simulations tested to conduct the experimental results. In the Section IV experimental results are shown considering that the desired local coordinates are dynamically given by some on-robot perception system. Experimental cost function tuning is a relevant issue developed in this section. The conclusion and future work are presented in Section V.

II. THE WMR KINEMATICAL AND DINAMICAL SYSTEMS

The WMR platform used in this research is a differential driven WMR with a free rotating wheel. The WMR basic description can be found in [8]. The Table I depict the main mechanical features of the PRIM available platform, designed for indoor navigation, used in this work. In the next two subsections the robot kinematical and dynamical systems are introduced.

A. The Kinematic System

The WMR is a rigid body and consequently non-deforming wheels are considered. It is assumed that the vehicle moves without slipping on a plane, so there is a pure rolling contact between the wheels and the ground. Denoting (x, y, θ) as the coordinates of position and orientation, and u

Modeling, Identification and Control of the Yaw Movement for a Miniature Coaxial Helicopter

Daniel Neamtu, Andres Hernandez,
Robin De Keyser, Clara Ionescu
EESA Department
Ghent University
Ghent, Belgium
Daniel.v.neamtu@gmail.com

Ioan Nascu
Automation Department
Technical University of Cluj-Napoca
Cluj-Napoca, Romania
Ioan.Nascu@aut.utcluj.ro

Abstract—**The advances in sensor technology, communication and micro-controllers have allowed the research community to develop such applications. In this paper we focus on the architecture of such a system, in the first part, while in the second part of the paper the modeling, identification and controller for the yaw movement of the helicopter is presented. The obtained controller was tested in real-life experiments with very good results.**

Keywords- coaxial helicopter, identification, control

I. INTRODUCTION

Helicopters pose special abilities which are not encountered in any other flying machine. Some of these special abilities are: hovering, vertical take-off – landing, low-speed cruise, pirouette etc.; which come together with a manifold of challenges. The helicopter dynamics can be characterized by a MIMO (Multi Input Multi Output) strongly coupled system with non-linearity and intrinsic instability [8]. Hitherto, the research towards modeling and control of such a UAV (Unmanned Aerial Vehicle) system has known an increased interest from the academic community, given the great number of papers and projects concerned with this topic. This major interest is due to the various applications of UAVs, both for military and civil purposes. A comprehensive list of civil applications is presented in [12], e.g. scientific missions, emergency missions, surveillance missions, industrial applications.

Figure 1 Big Lama coaxial helicopter

The application presented in this paper is a UAV platform based on a commercially available coaxial helicopter which is shown in Fig. 1. The final purpose of our research project is to achieve autonomous flight conditions suitable for surveillance in narrow spaces, e.g. inside a commercial center [3].

In this contribution, we present the first steps towards complete modeling, identification and control of coaxial helicopter. Initially, a SISO configuration is proposed, based on a simplified model, which enables control on one of the three axes – the Z axis (yaw). The identification is achieved using a revised form of the classical transfer function analyzer (TFA) algorithm; namely the Chirp-TFA formulated in [5]. Once the model is available, the design of the controller can be performed based on the desired specifications of the closed loop performance. For this purpose, the in-house FRTool (Frequency Response Toolbox) for Matlab environment has been employed [7].

The paper is structured as follows: in the next section the structure of the UAV system is presented (hardware and software), the 3rd section proposes a model for the yaw movement of a miniature coaxial helicopter, the 4th section deals with the identification of the yaw movements, in the 5th section the control strategy is presented and in the last section the paper is summarized and some further research is proposed.

II. UAV SYSTEM

A. Physical Architecture

The use of a coaxial helicopter for a UAV system development has been reported in several papers [3, 4, 13, 14]. This type of aircraft is easier to control than the single rotor helicopter and the power is used more efficiently due to the absence of a tail rotor. The UAV system consists of: 1) the aircraft to be controlled; 2) an on-board IMU (Inertial Measurement Unit) with sensors to determine the attitude of the aircraft; 3) bidirectional wireless communication; and 4) a ground-based computer in which the controller is implemented. A block representation of the hardware system is shown in Fig. 2. The arrows that interconnect the components indicate how data is transmitted through the system. Arrows including a lightning symbol represent wireless communication.

In general, for automatic control of a process, the controller must be able to send commands to the process and receives information about the output of the process. The communication inside the UAV system can be split in two communication links that connect the helicopter to a computer which runs the control algorithm.

Model-based Electrical Energy Optimization of Industrial Automation Systems

Andreas Beck, Nasser Jazdi
Institute of Industrial Automation and Software Engineering
University of Stuttgart
Stuttgart, Germany
{andreas.beck; nasser.jazdi}@ias.uni-stuttgart.de

Abstract— **Energy optimization is one of the key challenges of the next decades. A first step for mitigation was made by research in the field of optimized technologies for energy consuming components, energy generation and energy transport. Despite this, energy optimization of complex systems during their operation time, regarding human-machine-interaction, has remained a challenge. This contribution proposes a model-based approach for electrical energy optimization of industrial automation systems. The approach serves as basis for decisions related to energy optimization issues. It considers the influences on the system's energy consumption, so that it allows a holistic view on energy consumption causes. Hence, a targeted selection of energy optimization measures becomes possible.**

Keywords-energy, analysis, industrial automation system

I. INTRODUCTION

Current surveys show a continuous shortage of conventional energy resources [1]. In contrast, the number of energy consumers steadily increases [2]. Reasons for this are both highly automated processes in industry, e. g. by integration of energy consuming devices for production automation, and the big number of electrical devices for home usage. This leads to raising energy costs, which are decisive factors of our economy. In consequence, politics, industry and research focus on regenerative energy sources and energy efficient technologies to lower the overall energy consumption. Typical electrical energy consumers are industrial automation systems. These have to be analyzed and optimized to reduce their energy demand.

Industrial automation systems encompass technical systems with included technical processes, computers and communication systems, and process operators involved [3]. Thereby a technical system can be a technical product or a technical plant, in which a technical process takes place. A washing machine is a typical example of a technical product, because it is a mass product with a high degree of automation, having few sensors and actuators. In contrast, a technical plant is a unique system with a large number of sensors and actuators and a medium to high degree of automation (e. g. a production facility).

To illustrate the problem and our approach we use an example that will be referenced throughout this paper. The example is a washing machine. The technical process in this case is the washing process that runs in the technical system consisting of all mechanical parts, like housing, drum and mechanical components of engine and heater. Actuators and sensors are electrical parts of engine and heater. The automation computer is a microcontroller that controls the technical process. The users interact with the washing machine by selecting a washing program, temperature, filling in laundry and cleaning agent.

Energy optimization of such a system can be performed both, during engineering or during operation of the industrial automation system. The general problem in engineering and development is that optimization is oriented on typical or expected situations in operation that must be defined in advance. Usually, the final application of the system is unknown at this moment. Hence, optimization in engineering alone is just a first step to optimize a system. The dynamic of influences (e. g. user interventions and changes in environmental conditions) may be considered first when the systems are in operation.

Industrial automation systems can be analyzed in operation by using either the real system, a prototype, or by model-based approaches like simulation or X-in-the-loop. Real systems and prototypes have the advantage of delivering real data. They implicitly regard all influences on the system. Model-based approaches spare measurement equipment and are easy to modify, but imply the risk of losing important details by abstraction. Model-based approaches are applicable for every kind of industrial automation systems. However, prototypes are rarely applicable for large and complex systems such as industrial facilities.

We intend to find a general solution for electrical energy optimization of industrial automation systems in operation. Therefore we propose a model-based optimization based on the analysis approach introduced in [4]. The approach takes into consideration all influences on industrial automation systems related to electrical energy consumption. Moreover, it provides capability needed in electrical energy optimization.

This paper is organized as follows. Section II presents requirements on electrical energy optimization of industrial automation systems. Section III describes the state of the art in model-based energy optimization. Our model-based approach is presented in section IV. The paper closes with a conclusion and an outlook on future work in section V.

II. REQUIREMENTS ON ENERGY OPTIMIZATION OF INDUSTRIAL AUTOMATION SYSTEMS

For energy optimization there are different approaches described in the literature. They all have in common a basic procedure to derive decisions on energy optimization measures. As an example we take a closer look at the phases of a benchmarking project described in [5]. As depicted in Figure 1 six phases exist. The first phase serves for selection of a benchmarking object (e. g. a technical product or plant).

Artificial Neural Network for intelligent Manufacturing System

Angela Egri*, Vali-Chivuța Sîrb*,
Adrian-Marius Tomuş*
*Department of Automatics, Applied Informatics and Computer Science
University of Petrosani, Petroşani, Roumania (e-mail: adi_tomus@yahoo.com)

***Abstract*—Our goal was to create an application that uses artificial neural networks for Optical Character Recognition. For this purpose we created a multilayer perceptron neural network which is trained using the backpropagation algorithm. The software application was created using the C# programming language. In few examples, we present the responses of the net to various input vectors.**

Keywords - artificial neural network, multilayer perceptron, backpropagation.

I. INTRODUCTION TO NEURAL NETWORKS

In this paper we present a neural network that can be used for Optical Character Recognition

The neural network consists of a number of interconnected processing units called neurons and is a distributed parallel processor that has a natural tendency to learn. It is similar to the human brain in that it can accumulate knowledge through learning and the knowledge the network gains is not stored in the neurons themselves but in the weights of the neurons. The neurons in an artificial neural network are grouped together in layers.

There are many ways of connecting neurons in a neural network. One type of neural network is the feed forward neural network in which the output of a neuron in one layer is tied to the input of a neuron in the next layer.

Probably the most used type of neural network is the Multilayer Perceptron. In this type of network the neurons perform a weighted sum of their inputs and pass this value to the transfer function to produce the output. This type of networks can model functions of almost arbitrary complexity, with the number of layers, and the number of units in each layer, determining the function complexity. A multilayer perceptron usually has an input layer, a hidden layer and an output layer [1].

The procedure used to train a neural network is called a learning algorithm. The goal of using this learning algorithm is to systematically adjust the synaptic weights of the net until we get the desired result. The most significant property of a neural network is its ability to learn through its environment and by doing this improving its performance.

III. SOFTWARE DESCRIPTION

The neural network used in this application has a Multilayer Perceptron architecture consisting of an input layer, a hidden layer and an output layer. The neurons in one layer of the network are connected to every neuron in the previous layer. The input layer of the used network has 35 neurons and each of these neurons has 35 inputs. The hidden layer has 50 neurons each with 35 inputs and the output layer has 36 neurons each with 50 inputs. Each neuron in the output layer corresponds to a letter or a digit that the network has to recognize. Each neuron in the network uses a sigmoid activation function [5].

The software uses two structures (Neuron, figure 1a and NeuronLayer, figure 1b) and a class (NeuralNet). The Neuron structure f is used to hold each neurons data, like the number of inputs, the output and the weight for each input. The bias of each neuron is included in the array of weights for each neuron.

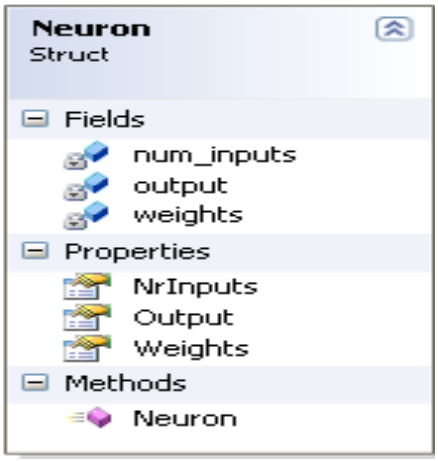

Figure 1 a) Neuron structure

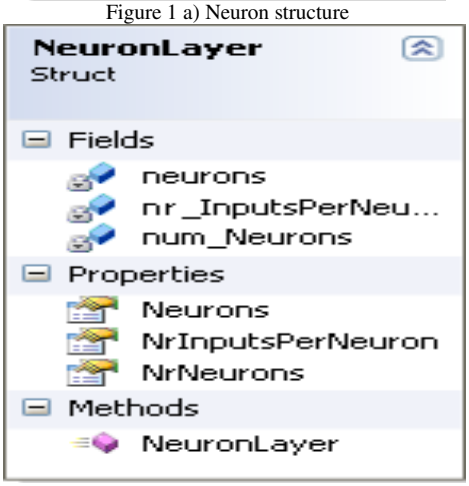

Figure 1 b) NeuronLayer structure

The NeuronLayer structure is used to group more neurons together to form a neuron layer. This structure holds

Feature Selection for Wireless Sensor Network's Data

Maria Muntean, Ioan Ileană, Mircea Rîşteiu, Manuella Kadar
Computer Science Department
"1 Decembrie 1918" University of Alba Iulia
Alba Iulia, Romania
e-mail: mmuntean@uab.ro

Honoriu Vălean
Automation Department
Technical University of Cluj Napoca
Cluj Napoca, Romania
Honoriu.Valean@aut.utcluj.ro

Abstract— **Classification of sensory data is a major research problem in wireless sensor networks (WSNs) and it can be widely used in reducing the data transmission in WSNs effectively, and also in process monitoring.**

In order to examine the huge size of dataset in the stream model generated by our sensor network, we analyzed different number of sensor parameters and number of acquisition data. In our wind energy monitoring, sensors node monitor six attributes: speed, direction, temperature, pressure, humidity, and battery voltage. Every attribute value is set as four measures: average, instantaneous, minimum and maximum.

Most of the time a lot of data means better results. This case is not valid all the time because sometimes we have a lot of redundant data and a lot of attributes that are weakly related to what we are trying to find out by evaluating the data.

Our purpose was to select the relevant features of the dataset and to reduce the time spent for the evaluation of the dataset. The Wrapper Subset Evaluation feature selection method implemented used a Best First Search and evaluated each of the attribute subsets according to Support Vector Machine learning scheme.

Keywords- Learning Algorithms, Classification, Accuracy, Improvement, Wireless Sensor Network

I. INTRODUCTION

Wireless sensor network (WSN) is an active research area with numerous applications. WSNs have been successfully applied for environment and security monitoring, object tracking and so on ([1], [2], [3]). It is a more challenging area related to data mining in WSNs, since sensor nodes have only limited resources (energy, storage, computation, power supply, and bandwidth).

Basically, what data mining tell us is that the more features we have, the better it is to make more accurate predictions about future instances. Practically, the amount of training data is limited, and excessive features are going to slow down the learning process. This is also one of the main causes why classifiers over-fit the training data, and perform poorly when faced with real life problems. Due to the large dimensionality, much time and memory are needed for training a classifier on a large collection of data.

Feature selection, an important knowledge discovery in databases pre-processing method, [4], tries to find the minim subset of the training data set, such that, this subset to be equal or as close as possible to the data set that the algorithm is actually going to use in order to train its model. The main idea is to keep the data that bring the most amount of information for learning how to evaluate future data that are going to be fed to the system and to discard the features that do not bring any new information.

II. SUPPORT VECTOR MACHINE

As a machine learning, we used the Support Vector Machine (SVM), a new classification method based on Statistical Learning Theory. Proposed by Vapnik and his colleagues in 1990's, [5], SVM is widely used in the area of regressive, pattern recognition and probability density estimation due to its simple structure and excellent learning performance. Joachims validated its outstanding performance in the area of text categorization in 1998, [6]. SVM can also overcome the over fitting and under fitting problems, [7], [8], and it has been used for imbalanced data classification [9], [10].

The SVM technique is based on two class classification. There are some methods used for classification in more than two classes. Looking at the two dimensional problem we actually want to find a line that "best" separates points in the positive class from the points in the negative class. The hyperplane is characterized by the decision function $f(x) = \mathrm{sgn}(\langle w , \Phi(x)\rangle + b)$, where "w" is the weight vector, orthogonal to the hyperplane, "b" is a scalar that represents the margin of the hyperplane, "x" is the current sample tested, "Φ(x)" is a function that transforms the input data into a higher dimensional feature space and "," representing the dot product. Sgn is the signum function. If "w" has unit length, then $\langle w, \Phi(x)\rangle$ is the length of "Φ(x)" along the direction of "w".

To construct the SVM classifier one has to minimize the norm of the weight vector "w" (where ||w|| represents the Euclidian norm) under the constraint that the training patterns of each class reside on opposite sides of the separating surface. The training part of the algorithm needs to find the normal vector "w" that leads to the largest "b" of the hyperplane. Since the input vectors enter the dual only in form of dot products the algorithm can be generalized to non-linear classification by mapping the input data into a higher-dimensional feature space via an a priori chosen non-linear mapping function "Φ" and construct a separating hyperplane with the maximum margin.

In solving the quadratic optimization problem of the linear SVM (i.e. when searching for a linear SVM in the new higher

Transient Analysis of the Switched Vacuum Overvoltages Limited using Some Surge Suppressors

R. Dobra*, M. Rasteiu**, C. Zoller* and M. Friedmann***
* University of Petrosani, Department of Electrical and Power Systems
Petrosani, Romania, e-mail: dobra@upet.ro, zoller_carol@yahoo.com
** "1 Decembrie 1918" University of Alba Iulia, Computer Science Department
Alba Iulia, Romania, e-mail: mristeiu@uab.ro
***National Institute for Research and Development in Mine Safety to Explosion, Laboratory for Explosion-Proofnes
Petrosani, Romania, e-mail: friedmann@insemex.ro

Abstract—**In low voltage power electrical circuits where switching operations are made through the contactors or vacuum circuit breakers, switching transient overvoltages (TRV) occurs. When disconnect a vacuum contactor in between this device and consumer electromagnetic energy accumulates and thus overvoltages are generated which additional overcharge the electrical insulation. To prevent undesirable switching overvoltages while switching inductive circuits, the transient overvoltages must be limited to the lowest possible values and for this dedicated devices are known as transient surge suppressors or transient voltage suppressors (TVS). A measuring circuit for transient switching overvoltage allows determination of their shape and maximum values obtained from using new types of transient voltage suppressors. The study was performed using a data acquisition board connected to a PC via a USB connection and HP VEE Pro 8.0 software, also used to design the theoretical model of switching transient overvoltages parameters.**

Keywords- circuit simulation, transient analysis, vacuum breakers, overvoltages, surge suppressor, HP VEE Pro 8.0

I. INTRODUCTION

Disconnecting an electrical circuit via a vacuum contactor, each of the networks at eider side of the breaker proceeds to redistribute its trapped energy. As a result of this energy distribution, each network will develop a voltage that appears simultaneously at the respective terminals of the breaker. The algebraic sum of these two voltages represents the transient recovery voltage.

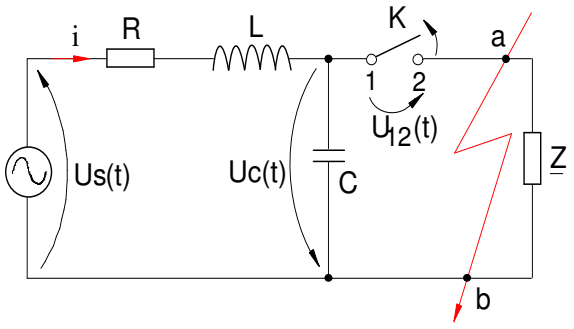

Figure 1. Simplified model of the disconnected circuit were

$$u_s(t) = \hat{U}\ sin(\ \omega t + \varphi\ )$$

The recovery voltage phenomenon depends on the conditions that prevail at the moment of the current interruption and has an oscillatory amortized shape because of the RLC network components. Documentation model that reflects this switching off situation consists of an RLC group disconnected from the load resistance by the K breaker (fig. 1) [1].

Transient recovery voltage expression has two components namely periodical component and aperiodical component given by (1).

$$u_{12}(t) = \frac{\hat{U}\ sin(\omega t + \varphi - \varphi_1)}{C\omega\sqrt{R^2 + \left(\frac{1}{C\omega} - L\omega\right)^2}} + \frac{D\hat{U}\cdot e^{-\delta t}}{2LC\omega_e^2} sin(\omega_e t - \gamma) \quad (1)$$

Equation 1 elements represent:

$$\delta = \frac{R}{2L}; \omega_0^2 = \frac{1}{LC}; \omega_e = \sqrt{\omega_0^2 - \delta^2}; \omega = 2\pi f \quad (2)$$

$$D = \sqrt{A^2 + B^2 - 2AB\ cos(\beta - \alpha)} \quad (3)$$

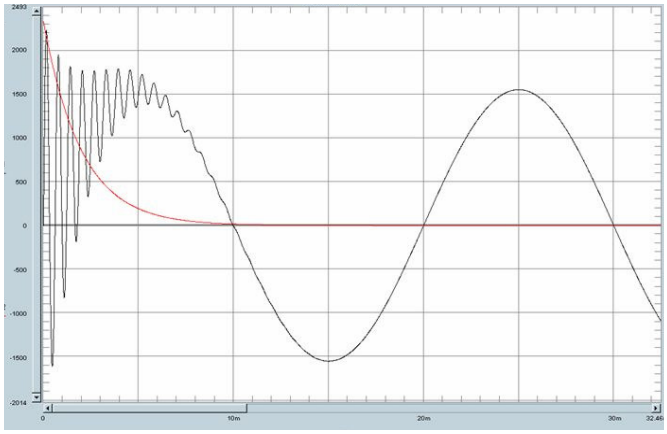

Figure 2. Transient recovery voltage

Exploiting policy knowledge in online least-squares policy iteration: An empirical study

Lucian Buşoniu
Team SequeL
INRIA Lille – Nord Europe
France
lucian@busoniu.net

Bart De Schutter, Robert Babuška
Delft Center for Systems and Control
Delft University of Technology
The Netherlands
{b.deschutter, r.babuska}@tudelft.nl

Damien Ernst
Institut Montefiore
FNRS & University of Liège
Belgium
dernst@ulg.ac.be

***Abstract*—Reinforcement learning (RL) is a promising paradigm for learning optimal control. Traditional RL works for discrete variables only, so to deal with the continuous variables appearing in control problems, approximate representations of the solution are necessary. The field of approximate RL has tremendously expanded over the last decade, and a wide array of effective algorithms is now available. However, RL is generally envisioned as working without any prior knowledge about the system or the solution, whereas such knowledge is often available and can be exploited to great advantage. Therefore, in this paper we describe a method that exploits prior knowledge to accelerate online least-squares policy iteration (LSPI), a state-of-the-art algorithm for approximate RL. We focus on prior knowledge about the monotonicity of the control policy with respect to the system states. Such monotonic policies are appropriate for important classes of systems appearing in control applications, including for instance nearly linear systems and linear systems with monotonic input nonlinearities. In an empirical evaluation, online LSPI with prior knowledge is shown to learn much faster and more reliably than the original online LSPI.**

***Keywords*—reinforcement learning, prior knowledge, least-squares policy iteration, online learning.**

I. Introduction

Reinforcement learning (RL) can address problems from a variety of fields, including automatic control, computer science, operations research, and economics [1]–[4]. In automatic control, RL algorithms can solve nonlinear, stochastic optimal control problems, in which a cumulative reward signals must be maximized. Rather than using a model as in classical control, a RL controller learns how to control the system from data, and online RL techniques collect their own data by interacting with the system. For systems with continuous or large discrete state-action spaces, as most of the systems encountered in automatic control, RL solutions cannot be represented exactly, but must be approximated [4]. State-of-the-art algorithms for approximate RL use weighted summations of basis functions to represent the value function (which gives the cumulative reward as a function of the states and possibly of the actions), and least-squares techniques to find the weights. Such techniques have been studied by many authors [5]–[10], and recently surveyed in e.g. [11]–[13].

One such algorithm is least-squares policy iteration (LSPI) [7]. At every iteration, LSPI evaluates the current control policy, by computing its approximate value function from transition samples, and then finds a new, improved policy from this value function. LSPI can efficiently use transition data collected in any manner, but originally works offline. In [14], we have introduced an online variant of LSPI, which collects its own data by interacting with the system, and performs policy improvements "optimistically" [3], [15], without waiting until an accurate evaluation of the current policy is completed. Such policy improvements allow online LSPI to learn fast, i.e., to achieve good performance after interacting with the system for only a short interval of time.

In this paper, we present a method to exploit prior knowledge in order to improve the learning speed of online LSPI. Although RL is usually envisioned as working without any prior knowledge, such knowledge is often available, and exploiting it can be highly beneficial. We consider prior knowledge in the form of the monotonicity of the control policy with respect to the state variables. Such monotonic policies are suitable for controlling important classes of systems. For instance, policies that are linear in the state variables, and therefore monotonic, work well for controlling linear systems, as well as nonlinear systems in neighborhoods of equilibria where they are nearly linear. Moreover, some linear systems with monotonic input nonlinearities (such as saturation or dead-zone nonlinearities) have policies that, while strongly nonlinear, are nevertheless monotonic.

We employ a policy representation for which monotonicity can be ensured by imposing linear inequality constraints on the policy parameters. This allows policy improvements to be performed efficiently, using quadratic programming. A speedup of the learning process is expected, because online LSPI restricts its focus to the class of monotonic policies, and no longer invests valuable learning time in trying other, unsuitable policies. The effects of using prior knowledge in online LSPI are illustrated in a simulation study involving the stabilization of a DC motor.

Several other online RL algorithms based on policy iteration and least-squares techniques have been proposed. For instance, [16] investigated a version of LSPI with online sample collection, focusing on the issue of exploration. This version does not perform optimistic policy updates, but fully executes offline LSPI between consecutive sample-collection episodes. An algorithm related to LSPI, called least-squares policy evaluation [6], was studied in the optimistic context in [17]. Another optimistic variant of policy iteration based on least-squares methods was given by [10]. However, these techniques do not exploit prior knowledge about the solution.

The remainder of this paper is organized as follows. The necessary theoretical background on RL, together with offline and online LSPI, are described in Section II. Then, in Section III, we introduce our method to integrate prior knowledge into online LSPI, and in Section IV, we present the results of our simulation experiments. Section V concludes the paper

Based on the paper "Using prior knowledge to accelerate least-squares policy iteration" by Buşoniu, De Schutter, Babuška, and Ernst, which appeared in *Proceedings of the 2010 IEEE International Conference on Automation Quality and Testing Robotics (AQTR)*, © 2010 IEEE.

Creating an EHR experimental model using openEHR specifications and EN/ISO 13606

O. Stan, D. Sauciu, I. Paun, L. Miclea, C. Dehelean
Department of Automation
Technical University of Cluj Napoca, Faculty of Automation and Computer Science
Cluj Napoca, Romania
ovidiu.stan@aut.utcluj.ro

S. Dehelean
Intelmed S.R.L.
Cluj Napoca, Romania

F. Stamatian
University of Medicine and Pharrmacy "Iuliu Hatieganu"
Cluj Napoca, Romania

Abstract—**The present article portrays a description of the proposed experimental model developed within a Romanian research grant and of the applied medical informatics standards.**

The proposed experimental model is a solution to ensure the accuracy, safety and the semantic interoperability of data by complying with openEHR specifications and EN/ISO 13606 communication standard.

The aim of the openEHR is to specify the structure of a medical database and the EN/ISO 13606, an extract from openEHR, represents a medical data communication standard. Both standards specify the principles and not the technologies or methods. (Abstract)

Keywords-openEHR, EN/ISO-13606, hospital information system, interoperability

I. INTRODUCTION

One of the most significant challenges we come across in the medical informatics domain is creating usable and common information. The idea of creating a patient electronic health record is quite old, since 1966, but is no yet a reality.

The Electronic Health Record (EHR) is a longitudinal electronic record of patient health information generated by several encounters in any care delivery setting. The EHR has the ability to generate a complete record of a clinical patient encounter - as well as supporting other care-related activities directly or indirectly via interface - including evidence-based decision support, quality management, and outcomes reporting [1].

The extensive amount of data involved has to be available throughout the lifetime of the patient. Accuracy is an absolute must in the field of medical information so that issues such as data mixing and loss can be pre-vented. Because in this field involves personal and medical data, the system must provide a safe environment and the information should be accessed only by users with proper clearance.

Classical medical information systems that are now on the market are based on a single level of modeling where the domain concepts are encoded directly in software and database. Although this approach allows rapid development, the adaptation to frequent changes in health field is extremely expensive. Is the adaption is not achieved, they will be outdated. For example, clinical knowledge define that for a measure of a patient's blood pressure we need two values, systolic and diastolic. The medical system can store these values by implementing a table in database with two columns (knowledge became a part of the data model used). A systems thus created can operate correctly for a while, but if the future research in the field conclude that for a precise measurement of patient's blood pressure we need also the position of the patient during the procedure (changes in the knowledge that entails a change in the concept domain) the system need to be upgraded. Another problem is that these approaches limited the interoperability between different applications.

The proposed experimental model was designed for Romanian healthcare through a founded research grant project named DESP (acronym for the Patient's Electronic Health File). The partners involved in designing, implementing and testing of this experimental model are the Technical University of Cluj-Napoca (UTCN), the Cluj County Hospital (SCJU), the Municipal Hospital of Cluj-Napoca (SCM) and the Research Institute for Analytical Instrumentation (ICIA).

II. APPLIED STANDARD

Given the complexity of the medical system and the need of interoperability between different medical software solutions, the compliance to standards becomes a strict requirement.

A. openEHR

The openEHR Foundation is an independent non-profit community facilitating the creation and sharing of health records by consumers and clinicians via open-source and standards-based implementations.

The registered online community is composed of 1200 members from 75 different countries. It publishes evolving EHR design specifications, strongly underpinned by live clinical demonstrators, using a multi-model approach, including archetypes [2].

The openEHR approach distinguishes a Reference Model, used to represent the generic properties of health record information and Archetypes (conforming to an Archetype Model) which are meta-data used to define patterns for the specific characteristics of the clinical data representing the requirements of each particular profession, specialty or service.

The Reference Model represents the global characteristics of health record components, the way they are aggregated and the context information required to meet ethical, legal and provenance requirements. This model defines the set of classes forming the generic building blocks of the EHR. It

Interoperability of EHRs in romanian Healthcare System

D. Sauciuc, I. Paun, O. Stan, L. Miclea, C. Dehelean
Department of Automation
Technical University of Cluj-Napoca, Faculty of Automation and Computer Science
Cluj Napoca, Romania
ovidiu.stan@aut.utcluj.ro

S. Dehelean
Intelmed S.R.L
Cluj Napoca, Romania

F. Stamatian
University of Medicine and Pharmacy "Iuliu Hatieganu"
Cluj-Napoca, Romania

Abstract—**This article approaches the main challenges of the medical field in ensuring efficient and safe exchange of electronic healthcare records. It presents a solution for the interoperability problem by applying the openEHR and EN/ISO-13606 standards as part of the DESP Romanian research project.** *(Abstract)*

Keywords- electronic healthcare records, openEHR, EN/ISO-13606, hospital information system, interoperability, archetypes

I. INTRODUCTION

Worldwide, the medical field is undergoing an important movement of improving the quality of healthcare. Among the major problems that must be solved stand ensuring continuity of care, safety and confidentiality of information and efficient use of resources.

In most of the cases, a team of health professionals work together in order to provide the best care of patients. Because medicine is moving from a single physician to a team of physicians from numerous medical units, medical information systems must be more efficient. The quality of medical services depends on the timely and appropriate transfer of activity and information. Continuity of care can only be achieved by correct and efficient exchange of information about the health of patients between different providers.

The electronic healthcare record (EHR) is defined by ISO TC215 Health Informatics Standard as "a longitudinal collection of personal health information concerning a single individual, entered or accepted by health care providers, and stored electronically. The information is organized primarily to support continuing, efficient and quality health care and is stored and transmitted securely." The EHR includes all the information regarding a person's health throughout his life including: laboratory tests, imaging reports, treatments, diagnostic, therapies, allergies, drugs administered, patient identifying information. The most important function of EHR is the ability to share health information among different authorized users. This requires interoperability of information in the EHR and interoperability of EHR systems which exchange and share this information.

In general interoperability is defined as the ability of two or more parties to exchange and use information.

In the medical information field three types of interoperability stand out [1]:

- "interoperability of electronic health record systems" the parties involved are electronic health record systems; the data exchanged is both computer and human readable information and knowledge
- "cross-border interoperability" means interoperability between different countries and their entire territories
- "semantic interoperability" means ensuring that the precise meaning intended by the original author is understandable by any other system or application

The European Commission's Recommendation on cross-border interoperability of electronic health record systems defines interoperability of EHRs as one of the union's priorities. The Recommendation is based on the premise that connecting people, systems and services is vital for a good healthcare across Europe as it is necessary to enable the free flow of patients as well as eHealth products and services, and hence may contribute significantly to the growth of the internal market.

Lack of interoperability of electronic health record systems is one of the major obstacles in front of the benefits of eHealth in the Community. Market fragmentation in eHealth is characterized by the lack of technical and semantic interoperability. The health information and communication systems and standards currently used have the disadvantage of being incompatible and do not facilitate access to vital information. Overall European eHealth interoperability is desired to be achieved by the end of the year 2015.

DESP is a Romanian research project focused on developing a feasible software solution for the Romanian healthcare system based on the openEHR and EN13606 standards. The partners involved are the Technical University of Cluj-Napoca (UTCN), the Cluj County Hospital (SCJU), the Municipal Hospital of Cluj-Napoca (SCM) and the Research Institute for Analytical Instrumentation (ICIA). The name of the project is an acronym for the Patient's Electronic Health Record (DESP). The research started in 2007 and covered four phases out of the total number of five.

The application is a response to the need of the healthcare system from Romania to improve its services. Romania was on the 25th place from the 29 states compared in the 2007 European Health Consumer Index put forward at 1st October 2007 in Bruxelles. According to this index, our country had a low score because healthcare personal did not have access to healthcare records in an electronic format.

Modeling and Simulation of a Petrochemical Hydrogenation Process

Roxana Both, Clement Festila, Eva-Henrietta Dulf
Department of Automation
Technical University of Cluj-Napoca
Cluj-Napoca, Romania
roxana.both@aut.utcluj.ro

Abstract— **The 2 ethyl-hexenal consecutive hydrogenation reactions in order to obtain 2 ethyl-hexanol, were studied in the liquid phase in presence of commercial Ni-Si catalyst. The aim of this paper is to develop a mathematical model that can describe the temperature evolution besides the component concentration evolution. The developed model is based on the kinetic equations, energy balance conservation law and mass balance conservation laws. The evolution of the process variables can be validated using experimental data. The actual computer based process simulation techniques are an essential tool for control design and for optimal operating condition determination.**

Keywords-mathematical modeling; hydrogenation process; chemical reactor

I. INTRODUCTION

At present, one of the most important petrochemical processes is the production of oxo alcohols on an industrial scale (plasticizer alcohols). 2 Ethyl-hexanol (2-EH) and n-butanol represent 70% of global consumption of plasticizers alcohols. Plasticizers manufacturers represent by far the largest market for plasticizers alcohols representing almost 49% of the total global consumption.

The C3-C8 aldehydes result as products of oxo-processes. The oxo-aldehydes are not important as final products. However, oxo-aldehydes are important intermediary reactive products in the production of oxo-alcohols or carbonilic-acids. Large quantities of oxo-alcohols are produced and used as feedstock in the production of plasticizers, detergents and lubricants. 2 Ethyl-hexanol is mainly used in the production of plasticizers, adhesives and other specialty chemicals. In the plasticizers industry 2 ethyl-hexanol is used as a raw material in the production of dioctyl-phthalate (DOP) or 2 ethylhexyl-phthalate(DEHP). Both the DOP and DEHP are used to manufacture poly-vinyl-chloride (PVC). There are a number of other uses for 2 ethyl-hexanol. It is used as solvent with low volatility for waxes, animal fats, vegetable oils, disinfectants, insecticides sprays and petroleum derivatives. The 2 ethyl-hexanol derivatives are used as additives for diesel fuel to reduce emissions and to improve the performances of lubricant oils (Lube oils).

The industrial synthesis of 2 ethyl-hexanol is a three-stage process involving the aldol self-condensation of n-butyraldehyde, followed by dehydration and hydrogenation. The hydrogenation of 2 ethyl-hexenal is an important step for the industrial synthesis of 2 ethyl-hexanol. The hydrogenation stage takes place inside isothermal hydrogenation reactors in the presence of Ni-Si catalyst.

The hydrogenation reaction [5] is a class of chemical reactions, where the net result is the addition of hydrogen (H_2). The products generally used in hydrogenation processes are unsaturated organic compounds, like alkenes, alkynes, nitrils and aldehydes. The unsaturated aldehydes hydrogenation reaction occurs at high speed in the presence of noble metal catalysts group. Depending on the type of catalyst used and reaction conditions there can be two types of reactions:

- liquid phase catalytic reactions: hydrogenation in the liquid phase;
- vapor phase catalytic reaction: hydrogenation in gas phase.

Some of the advantages of the liquid phase hydrogenation are: high selectivity, small dimensions of the equipments, small fluxes of hydrogen, low energy consumption and small volumes of catalyst. The only drawback is the impossibility to regenerate the catalyst. Regarding the gas phase hydrogenation the main advantage is the possibility of catalyst regeneration. The drawbacks of the gas phase hydrogenation are: high energy consumption, the great dimension of the equipments, and the big volumes of catalyst needed.

Broadly, the basic chemical reaction of the hydrogenation process scale involves industrial gas hydrogen, used as a reactant and a catalyst to accelerate the reaction, usually at high temperature and certain pressure. Most hydrogenation processes use metallic catalysts to "break" the hydrogen and to stabilize temporarily produced radicals. These enabled hydrogen atoms are highly reactive and will try to reconnect to other chemicals. This involves breaking the double carbon bond, replacing one carbon bond with a new carbon - hydrogen bond.

The hydrogenation reaction mechanism involves absorption of 2 ethyl-hexenal, aldehyde and hydrogen molecules on the active surface of the catalyst. Hydrogen is dissociated to atomic form and is linked through the non-participating electrons from carbonyl group or from the double carbon atoms bound.

Due to higher electronic density of oxygen atom, the carbonyl group is more easily hydrogenated and gets hydrogenated first. Depending on the catalyst type either both reactive groups can be hydrogenated (the carbonyl group and the double carbon atom bound) or just one of them. However, in the industrial process the selective hydrogenation of the double carbon atom bound has higher importance.

The 2 ethyl-hexenal hydrogenation reaction has 2 important steps. The first step is the hydrogenation of the 2 ethyl-hexenal to 2 ethyl-hexanal. The second step consists of

Method for Predictive Control of Blood Glucose

Eugen Iancu
Department of Automation, Electronics and Mecatronics
University of Craiova
Romania
E-mail: Eugen.Iancu@automation.ucv.ro

Ionela Iancu
Department of Physiology
University of Medicine and Pharmacy of Craiova
Romania
E-mail: ep.iancu@gmail.com

Abstract— **The blood glucose control is a significant part of the medical practice regarding diabetes and critically ill patients. This paper presents a time-delay model of the cardio-vascular system implemented in a predictive control structure for the controlling of the blood glucose level. The Smith predictor was used in order to synthesise the control law.**

Keywords - blood glucose control, cardiovascular system, predictor Smith, model predictive control.

I. INTRODUCTION

The diabetes mellitus is a disease with serious social implications through the large number of people affected, complications and high costs that it involves. The World Health Organization has estimated a rapid increase in the number of people affected by diabetes mellitus from 173 million in 1973 to 300 million in 2025. Studies regarding the increase of morbidity through diabetes, especially at children or youngsters and grave complications of this disease have allowed the anticipation of high costs at the society level.

The realisation of the artificial pancreas is presently a fundamental high priority research area with a strong interdisciplinary character (physiology, diabetology, automated systems engineering). The objective consisted in the building of a mathematical model of the blood glucose (BG) control system as correctly as possible and the development on its base of evolved control algorithms in an automated state, adapted to the real-life situations encountered in medical practice. The realisation of these algorithms constitutes an important stage in the construction of insulin pumps with automated control (closed loop) similar to the physiological pancreas. These algorithms are indispensable to the realisation of monitoring and assistance systems for patients in a critical state or at intensive care and also, in islet cells transplantation to avoid the large oscillations of the BG.

II. METHOD FOR MONITORING AND THERAPY

The modern concept on the artificial pancreas has been put across in 1983 with the appearance of the first commercial variant of the insulin pump. Numerous projects and studies have had the purpose of designing the equipments capable of substituting the physiological system for the glycaemia control in the human organism. Presently, there are two main research directions with the artificial pancreas as a main purpose:

- The insulin pump
- Monitoring and assistance systems for patients in a critical state, affected by diabetes or not.

The insulin pump is a small device that is placed outside the body or is implanted into the body containing an insulin reservoir and a catheter for the introducing of insulin into the body, a sensor for the measuring of the glycaemia and a controller that calculates the body's need for insulin and commands an electric micro-pump to release the insulin.

The sensor used for the measuring of the BG can be placed under or on the skin, case in which the device is similar to a wristwatch. The tested methods are of great diversity: the oxidation reaction of glucose, reverse ionophorese, micro dialyse, spectroscopy, techniques based on the laser and fluorescent lights. The sensors measure the glucose concentration at 5, 15 or 60 minute intervals, and transmit the information through a cable connected to the body of the pump or wireless. Basically, the sensors can realise the monitoring of the glycaemia with exceptional results:

- The continuous recording of the glycaemia values and their tendencies.
- The recording of all hypoglycaemia or hyperglycaemia episodes.

The limits of the insulin pump, due to the sensors, consisted in the medical point of view in possible complications (infections, detachments or false readings) and the necessity of replacement at relative small periods. From the precision point of view, a high dispersion of measurements has been seen. Also, the sensors have different time constants, depending on where they are located, intravenous, subcutaneous, or on the skin. The catheter for the infusion of insulin can be located intravenous, subcutaneous or intra-peritoneal. For every administration, way there is absorption curve specific for insulin, time constants and action periods that impose the particularisation of the glycaemia control algorithms.

The insulin pump ensures the continuous administration of insulin, in a basal dose, similar to the physiological pancreas and allows the administration of insulin in bolus through the direct command of the patient or the medical care staff. This direct insulin control system adapts the necessary insulin quantity in the case of food intake, physical effort, during sleep or at patients found in a critical state and assisted in the intensive care section. In these conditions, the determining of the insulin dose requires a good patient training and experience in the necessary quantity of insulin vis-à-vis to the disturbing situation.

The used type of insulin also imposes the particularisation of the algorithm, in the case of automated or semi-automated control of the insulin pump. The use of the fast action insulin ensures a better pharmacokinetic inside the organism, lower

Cemented versus uncemented glenohumeral joint during external and internal rotation

Mihaela Manisor, C. Marcu, L. Miclea
Department of Automation
Technical University
Cluj-Napoca, Romania
Mihaela.Manisor@aut.utcluj.ro
Cosmin.Marcu@ aut.utcluj.ro
Liviu@aut.utcluj.ro

G. Tomoaia
"Iuliu Hatieganu" University of Medicine and Pharmacy
Cluj-Napoca, Romania
tomoaia2000@yahoo.com

***Abstract*—A finite element modeling was performed in order to study the glenohumeral joint. A comparison study was conducted between the cemented and uncemented prosthetic humerus. We simulated the external and internal rotation of the glenohumeral joint in order to compare the deformation, strain and stress appeared uncemented prosthesis with the prosthetic one. The results show that for the external and internal rotation the solicitation typically appeared in the same humeral positions but the mechanical solicitation for the uncemented prosthesis has smaller numerical value. This study is innovative due to the fact that it considers all muscle groups involved in external and internal rotation and obtains a realistic estimate of the mechanical solicitations appeared into the humerus. Possible fracture risk can be determined and prevented in case prosthesis is implanted. It will be used to test different types of shoulder movements and materials and to determine the optimal cement type.**

Keywords-finite element, biomechanics, prosthesis, shoulder rotation

I. INTRODUCTION

Orthopedic implants are intended to support forces and must thereby be firmly attached to the rest of the skeleton[1] D.R. Carter and G.S. Beaupr'e, Skeletal function and form, Cambridge University Press, Cambridge, United Kingdom (2001). [1]. Orthopedic implant devices are intended to restore the function of load-bearing joints which are subjected to high level of mechanical stresses, wear, and fatigue in the course of normal activity [2].

The implant is placed in the body either with an acrylic cement that gradually fails as regeneration of connecting bone tissue is proceeding, or without cement using an implant with an interface designed to provide the necessary attachment. However, a device fabricated from a single material usually cannot meet all physical requirements for successful implantation and function. Therefore, implants and prostheses usually consist of composites and mixtures or alloys [3]

The problem of the prosthesis material to be used still remains open. There is a need for high bonding inorganic surfaces to organic ones, and the development of materials durable and resistant to various types of mechanical solicitations. The prosthesis is usually built from biomaterials, which are synthetic or natural materials intended to function appropriately in a bio-environment. In fabricating a biomedical implant aimed at restoring the function of a body tissue, one is concerned about the mechanical properties of the material, design, and its biocompatibility. The material or system of materials chosen should have the appropriate mechanical properties such as elasticity, yield stress, ductility, toughness, wear resistance, etc. [2]

Titan alloys are very often used in building shoulder prosthesis, because in comparison with other metallic biomaterials, titanium and titanium alloys are more biocompatible, more corrosion resistant, lighter, more durable, and possess a reasonable balance of high strength and low elastic modulus. Titan alloys are not only biocompatible, but support cell attachment as well [4].

Efforts to increase bone ingrowth of cementless prostheses have led to the application of hydroxyapatite (HA) coating. Hydroxyapatite is chemically similar to the mineral component of human bones and hard tissues. It is able to support bone in-growth and osteointegration when used in orthopedic, dental, and maxillofacial applications. Moreover, HAp coatings have the capacity to shorten the healing process of metal based implants. The use of hydroxyapatite (HA) has been advocated to provide rapid and reliable attachment of bone to metal implants [5].

Another open question beside the type of material used is cemented versus uncemented prosthesis. Gupta et al [6] showed that the implant–bone interface, for uncemented design was subject to higher stresses as compared to cemented design. However, the implant–bone interface appeared less probable to fail at moderate loads, since higher interface bond strength was offered by higher bone density. Stresses in the polyethylene component were reduced for uncemented prosthesis as compared to the cemented ones, which may imply less polyethylene wear. Increasing the stiffness of the cup, by adding metal-backing, the stresses in the polyethylene liner decrease. The cancellous bone, underlying the uncemented prosthesis was subject to lower stresses as compared to cemented glenoid components.

Because of the difficulty of performing implant tests in vivo, mathematical models have been developed to carry out the structural analysis of implants before application on a patient. Accordingly, bone-implant scapulohumeral prosthesis could be designed and studied with computer simulations. To design highly durable prostheses one has to take into account the natural processes occurring in the bone. In most cases, these models consider that the bone is anisotropic even though the reality shows otherwise. This approximation is imposed due to the fact that there is no database containing the mechanical properties of the bone according to the model topography [8].

Many physical or computer models of the scapulohumeral joint have been developed to improve understanding of its function. Some were developed to understand and analyze muscle action developed during certain movements of the

Integrated Cascaded Hydropower Plants SCADA Operative System with Decision Support Components

Sz. Balogh, E. Stancel, B. Gyurka, C. Vigu, S. Ignat
SC IPA SA
Cluj Subsidiary
Cluj-Napoca, Romania
e-mail: bszabolcs, vigucristi @gmail.com,
eugen_stancel, gybz79, sorin_ign@yahoo.com

Abstract—**Current hydropower plants management techniques need efficient strategy to maximize the power production, improve the availability of technological equipment and reduce the overall maintenance costs.**
The SCADA Operative System for the Management of Cascaded Hydropower Plants (HPP) assists the plant floor operators as well as the central dispatcher during different operating situations (standard operation of the cascade, flood and drought, water supply management, hydro dam's parameter supervision, equipment status forecast, power plants status diagnosis, environmental policies).
The decision support system (DSS) uses the process acquired (HDB) datasets, the constraint decision-making commands, different technological criteria and priority mechanism for different objectives in developing optimal operating policies. The authors' efforts were concentrated towards designing a decision support system for multipurpose operation of cascaded hydropower plants. The mathematical models support short-term/long-term operation of hydropower plants based on the exploitation experience and operational knowledge.

Keywords-SCADA; DSS; HPP; HDB; HPMS

I. INTRODUCTION

The hydropower plants perform a strategic function in the national electric power systems as they assure a low operating cost and significant flexibility in different operating conditions. The environmental influence of artificial lakes and the water used in different domains could be improved by means of skillful optimization of water reservoir management.
The SCADA systems offer information support for the management of water resources and power production, providing to the operators many software features such as: optimal dispatching of all the hydro power plants, remote control of the generating units, emergency shutdown, on line visualization of the technological parameters.
The paper proposes an operational model of the hydropower plants technological resource management. This model is focused on several objectives:

- the challenge of achieving optimal power production strategy;
- estimation of the cost for maintenance in various global condition;
- design alternatives for future extension of new equipment dedicated to the river basin control.

The hydropower plant management is in essence a dynamic task. Thus the water involved in power supply generation at one moment in time can be used for other purposes afterwards. The influence of restrictions, like constraint storage capacity are considered. Outcomes are derived for water allocation and the electricity price.
Cascaded hydropower plant optimization techniques help plant staff in attaining advanced plant efficiency and estimated performance of their assets, therefore improving aggregate plant availability and capability.
Optimization techniques based on decision-support tools constantly evaluate plant status and offer root-cause investigation in the event of technological parameters deviations.
Plant Control solutions ensure operation process of individual generating units as well as the integration of the flood procedures and river controls like hydro chain control, cascades control and hydrology control. Concentrating and simultaneously processing data acquired by hundreds/thousands of sensors/transducers makes the decision support system a key element in operational decisions.
The DSS use the information provided by the SCADA systems. By incorporating DSS functions in existing SCADA, the resulting advanced SCADA system has the following capabilities:

- HDB processing for hydropower efficient exploitation (water level, inflow-outflow, energy production, volume, trends, etc.);
- Processing information regarding hydrological forecast;
- Power generating equipment status monitoring;
- Hydropower production forecast for each power/micro-power plant based on daily energy demand and equipment availability;
- Hydropower equipment forecast (availability, status, failure forecast).

Multiagent System for Developing and Sustaining the Virtual Enterprises Mechanisms

Teodora Sanislav, Dorina Căpățînă, Ioan Stoian
IPA – R&D Institute for Automation Cluj-Napoca Subsidiary
Cluj-Napoca, Romania
email: teodora@automation.ro

Abstract — **Internet development coupled with information content management technologies on one hand and with workflow management technologies on the other hand, has a major impact on how economic actors play their role in the global business environment. This leads to a new way of business approaches, "virtual enterprise" - VE, where many economic agents associate in order to provide a specific service, which traditionally would be provided by a single enterprise. The aim of our research is to develop a multiagent system for VE creation and operation. The development of the multiagent system uses one of the available agent-oriented software engineering methodologies. The most appropriate methodology for VE multiagent system is selected based on more evaluation criteria presented in the paper. The analysis-to-implementation procedure of our system, following the INGENIAS approach, consists in the presentation of the following concepts: the organization, the internal behavior, the communication between agents.**

Keywords - virtual enterprise, business process management, workflow management systems, muti-agent systems, agent-oriented software engineering (AOSE) methodologies.

I. INTRODUCTION

Internet development, coupled with information content management technologies on one hand and with workflow management technologies on the other hand, has a major impact on how economic actors play their role in the global business environment. This leads to a new business approach, "*virtual enterprise*" - VE, where many economic agents associate in order to provide a specific service, which traditionally would be provided by a single enterprise. Many definitions are present in the literature concerning virtual enterprises; the following were selected as being more comprehensive:

"The virtual enterprise is based on the ability to create temporary co-operations and to realize the value of a short business opportunity that the partners cannot (or can, but only to lesser extent) capture on their own" [1].

"A virtual enterprise is a temporary alliance of enterprises that come together to share skills or core competencies and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks" [2].

The goal of the virtual enterprise is to create value from changing opportunities in its environment. As such, the VE is viewed more like an action, instead of an institution. Its agility, that is – allowing the creation of solutions for immediate opportunities, leads to three key characteristics of VE [1]. First, virtual enterprise creates value from changing opportunities in its environment, making the virtual organization distinct from traditional management approaches. Second, the virtual enterprise differentiates and integrates work under dynamic conditions, implying cooperation between distributed sites over a limited period of time. This is another feature that makes the virtual enterprise distinct from existing paradigms. Finally, the solutions that support the VE must have dynamic characteristics, as the VE is permanently adapting.

Because a VE is a manifestation of Collaborative Networked Organizations (CNOs), the Virtual Enterprise has a specified life cycle different from the organizational life cycle in terms of time spend on creation and dissolution. A short description of the CNO-life cycle according to [3] is presented below:

- *Creation* (Identification and Formation): During the initiation a strategic plan is made for the operational stage and the foundation of the CNO is executed by the constitution and actual start up.
- *Operation***:** Execution of operations within the defined scope of the strategic plan.
- *Evolution*: The context of virtual organizations is rapidly changing and therefore in continuous evolution of its operation within the current strategic plan, this means, minor alterations.
- *Metamorphosis or Dissolution*: Because a CNOs did gained much experience during it relatively short life they either keep the knowledge my metamorphosing into a new organization (changing its form) with a new purpose or dissolute.

II. CONCEPTS AND TECHNOLOGIES FOR VIRTUAL ENTERPRISES

A. *Workflow and Business Process Management Systems*

Enterprise modeling is a step forward towards externalization, towards accumulating and sharing the enterprise knowledge. This is a vital support for future evolution of the enterprise system. Every company can be regarded both from static (enterprise structure) and dynamic (workflow processes) points of view. The structural organization comprises entities and people and implies objectives, tasks, resources and relations. This issue is characterized by limitations for the workflow. The workflow control regards the data flow into the organization and defines the processes, allocates temporal windows for the processes, defines labor division, participants, objectives, results and the dependencies between these factors.

The business processes define very well the workflow into an organization, characterized by the labor division between multiple participants to activities, at different time frames and different locations. These processes are continuously repeated in the same manner, according to the validation rules. The real situation shows that the