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ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ»**

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В сборнике трудов представлены материалы по современным проблемам автоматического управления мехатронными и робототехническими системами, идентификации систем управления, обнаружения сигналов, содержатся результаты теоретических исследований и практической реализации научно-исследовательских работ.

Предназначен для студентов, аспирантов и научных работников технических специальностей.

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CONTENT

IMPROVEMENT IN QUALITY OF DEGREE OF ACCURACY IN EXTRUSION PROCESS

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Аннотация – В данной статье проводится исследование факторов, влияющих на диаметр пластиковой нити, а также рассматривается задача повышения качества пластиковой нити в процессе экструзии.

Introduction

A rapid prototyping method makes it possible to produce complicated parts based on computer 3D model. Most of the rapid prototyping methods can assemble models from a variety of widespread and special materials. The modern additive technology for the most of 3D-printers requires ABS-filaments or PLA-filaments, respectively, from ABS (Acrylonitrile butadiene styrene) polymer or PLA (Polylactic acid) polymer, with a diameter 1.75 mm or 2.85 mm, which used as a consumable material in 3D printing technology.

Filament obtained from plastic granules, which in case of ABS, is the products of oil and gas industry. Accordingly, the price of granules is much cheaper than the price of the finished product, even taking into account the cost of electricity consumed in the transformation of the granulate in the filament.

In this article has been investigated factors affecting the diameter of the plastic filaments, as well as considered the problem of improving the quality of the filament plastic in the extrusion process.

Statement of the problem

A great deal of research has been conducted at universities and research institutions to expand the applications of FDM technology and to improve the FDM process. Work has also been in progress in some organizations to develop new metallic or ceramic materials for rapid fabrication of functional components by FDM with higher mechanical properties [2, 3].

In operations of the 3D-printer basic parameters affecting the quality of the finished product and fidelity digital models is diameter of the plastic filament. Therefore, to improve the production of plastic filaments, it is necessary to investigate and correct the control loop diameter plastic filament.

In order to stabilize the diameter of the plastic filament, we must consider the dependence on other parameters such as the temperature in the heating zone of the screw, the screw speed, the pressure in each zone of the screw and others. Changing any of these parameters leads to a change diameter of filament.

The most important parameters that have a permanent effect on the change in the diameter of the plastic filament is heating temperature and screw speed. On the base of this parameters experiment has been finished on the real object.

Fig. 1 shows a graph of an experiment conducted on an extrusion installation showing the temperature dependence of the diameter.

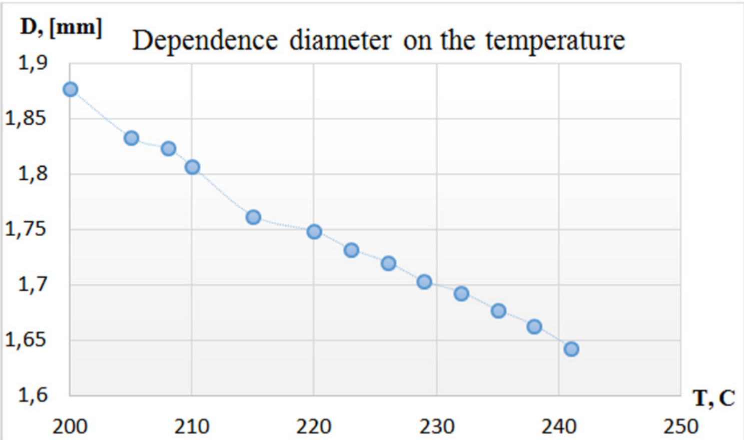

Fig. 1. Graph of the filament diameter of the temperature of the extruder

From the graph on the fig. 1 above it can be concluded that the higher the temperature, the smaller the diameter.

Analyzing the resulting graph fig. 2, we can conclude that by increasing the drive speed increases the diameter of the filament in the plastic extruder.

For a simple model of the extruder, changing control parameters as drive speed and the heating temperature is carried out manually. The influence of external factors not taken into account in the system, respectively, the system is not able to respond to external perturbations in the form of changes in ambient temperature, changes in the composition of raw materials, etc. thereby increasing the range of variation of the filament diameter.

The arguments above lead to the need for a system of automatic control of the diameter of a loop, which could provide the necessary accuracy and speed in the production process. Solve tasks can fully developed algorithm of adaptive digital PID control. Fig. 3 shows a functional line diagram of an extruder feedback.

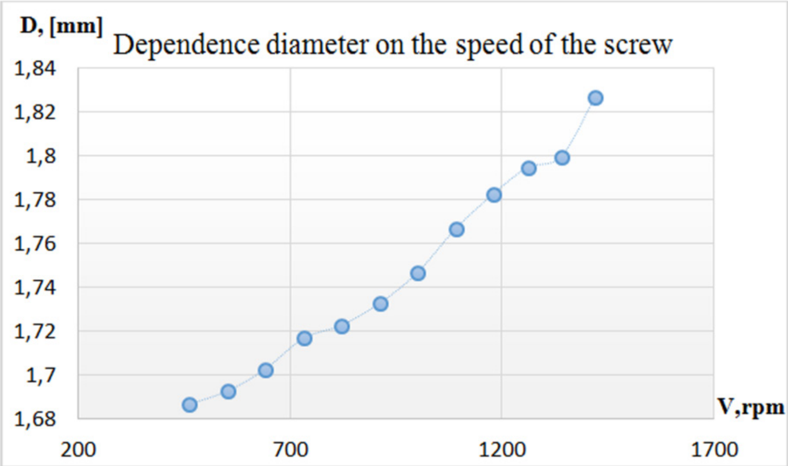

Fig. 2. It is showed the dependence of the diameter of the plastic filament on the rotational speed of the drive

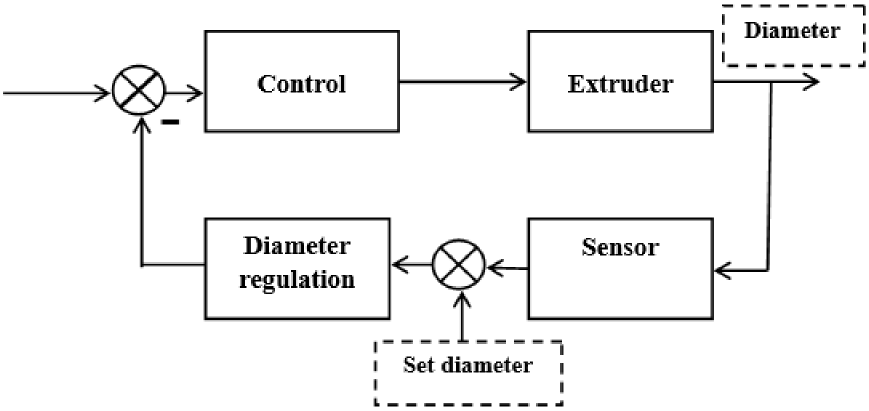

Fig. 3. Functional diagram of the extruder line with feedback

This diagram shows the connection of the probe diameter and electric installation, temperature sensor, and others. The controller is designed to form the control signal for diameter regulation when a signal comes from the sensor.

Conclusion

In this paper, conducted a study of factors affecting the diameter of the plastic threads, as well as consider the problem of improving the quality of the plastic thread in the extrusion process. The theoretical rationale for developing a feedback system for extrusion plant, which will improve the quality of the product, reduce the number of rejects, to ensure continuous operation for a long period.

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DESIGN OF THE TELEOPERATION ALGORITHM TO CONTROL THE HUMANOID ROBOT

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Abstract – This paper presents a concept design of work algorithm for teleoperation control system of humanoid robot. Humanoid robot control system needs to stabilize the robot in a vertical position in order to prevent the robot from falling. The process of design of the control system includes the design of position filter to detect the unstable positions. The application of such a control system enables to control the humanoid robot using motion capture technology.

Algorithm of the control system work

Humanoid robots are actively developed last years. There are many different designs of humanoid robot constructions but not all of them have control system that realizes adequate behavior of humanoid robot. That is why we propose to use the teleoperation [1], [2], [3], [4] to control such type of the robots. Further, we consider the algorithm of the teleoperation control system that allow control humanoid robots using the RGB-D sensor.

To form the control signals we need to collect the data about the human position. Let us create the operational block that process the data received from the RGB-D sensor. The objectives of this block are the forming of the packets with the human operator data and the initial data filtering, for example, forming of the packets only with the recognized position of the operator. When packet is filtered, system must inform the operator about it.

To control the position of the humanoid robot we need to set the positions of the actuators that are located in the joints of the robot. The positions of the actuators can be mapped from the angles of rotations in the joint of the human operator. It means that we need to receive the control signals that contains the information about angles of rotations.

The human body differs from the robot body because the mass of their limbs is different and it can be a reason of the robot falling that is why it is necessary to ensure the stable vertical position of the robot through the control process to prevent his falling. Thus, we need to filter unstable positions of the robot [5]. Only after all of these operations mapped and filtered positions of actuators can be sended to the robot.

Thus, we have an algorithm that can be showed as a row of actions:

- collecting filtered data,
- synthesising of actuators positions according to the data,
- filtering of actuators positions that make robot unstable,
- sending of actuators positions to the robot.

Conclusion

In this paper, we have described the concept design of the teleoperation system of humanoid robot. The designed control system allow the operator to control the robot using the motion capture technology that is the most ergonomic way of the humanoid control [6]. The system includes the stability control that filter all unstable positions of the robot. Whole system let us to control the humanoid robot effectively through the process of the movement. This paper describes only the concept of the control system and the further work is the implementation of this concept in a real control system of humanoid robot. At this moment, we realized the basics of the forming of the control signals (fig. 1) and started to realize the stability filter in the control system of the robot BIOLOID.

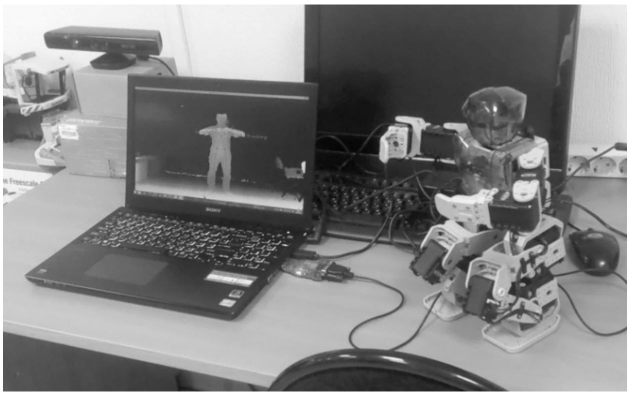

Fig. 1. First experiment on the control

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THE NEED OF REGULARIZATION FOR THE SYNTHESIS OF MULTI-LOOP CONTROL SYSTEMS

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Keywords: Multi loop control system, electric drive, regulator, real interpolation method, regularization.

Abstract – The article deals with the problem of the synthesis of multi loop control system. There is presented the substantiation of the need to using the regularization for solution the problem of the synthesis of multi-loop control systems. In addition, the base of the method of regularization represented there.

Introduction

The main questions of theory and practice of the Automatic Control Theory are related with the synthesis of the compensation, which system provides desired properties. The problem has completely solution for single-loop control systems.

When the synthesized system is multi-loop control system there are some problems, which do not provide a solution to a given accuracy for chosen criterions and structures.

Traditional for calculation a single-loop systems the method is the comparison of the desired transfer function and the transfer function of the synthesized system. Using it for design a multi-loop control systems leads to complex equations, which have several unknown variables. These parameters are determined by the structure of regulators and feedbacks [1].

The complexity of the equations is nonlinearity. Consequently in general for solving those equations is necessary to use an approximate methods solution search. The most popular way is the consistent calculation of circuits. The calculation starts with the internal circuit and ends the outer loop [2, 3]. Disadvantages this variant is obvious. The adopted scheme requires the distribution of desired system performances for each circuit synthesized system. This can be done only approximately. So the final result is the synthesis of additional error.

The desire to improve the accuracy of the construction of multi-loop control systems makes look for new ways to calculate the unknown coefficients, which not be using approximate methods such as the successive circuits synthesis. This is possible only if the initial equation synthesis may be permitted. Such method is presentation in this article.

1. Real interpolation method

The real interpolation method (RIM) is the one form of the operator method, that for every original-function $f(t)$ assigns to image-function $F(\delta)$ [1]. The image-function $F(\delta)$ can be calculated from the formula for the Laplace transform

$$F(p)=\int_0^\infty f(t)e^{-pt}dt,\ \ p=\delta+j\omega \tag{1}$$

if make the change the complex variable $p=\delta+j\omega$ on the real variable δ. Such replacement can be used only if the integral in equation (1) is convergent. This guarantees the existence and uniqueness of the function $F(\delta)$.

The RIM has such feature. The image of function $f(t)$ can be in analytical form $F(\delta)$ and in numeric form $F(\delta_i)$. The second has named the numerical characteristics and contains complete information about the original model. So using this form allows to solve such problem relatively simple.

The solution of the problem of synthesis of control systems by using the RIM base on the approximate equality of the numerical characteristics of the synthesized system and the numerical characteristics of the desired system

$$W_{closed}^{desired}\left(\delta_i\right)=W_{closed}^{synthesized}\left(\delta_i\right), \tag{2}$$

where δ_i – interpolation node, i – number of interpolation node.

2. The synthesis of the dual control system

The problem of the synthesis of the dual control system (fig. 1) is reduced to solving of equation (2).

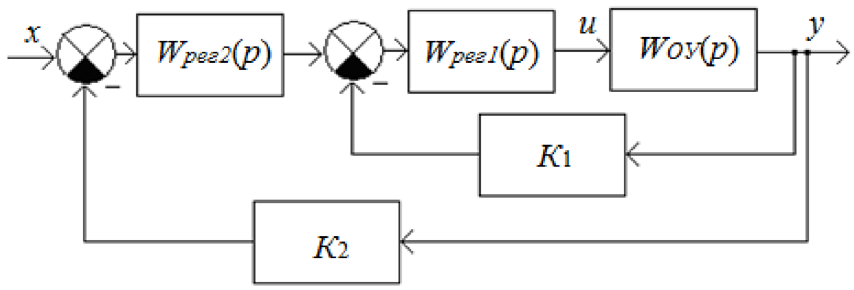

Fig. 1. Operator block diagram of a dual control system

Assume that the regulators $W_{reg1}(p)$ and $W_{reg2}(p)$ have the structures

$$\begin{aligned} W_{reg1}\left(p\right)&=\frac{b_{reg1_1}\delta+b_{reg1_0}}{a_{reg1_1}\delta+1}, \\ W_{reg2}\left(p\right)&=\frac{b_{reg1_1}\delta+b_{reg2_0}}{a_{reg2_1}\delta+1}. \end{aligned} \tag{3}$$

So, one can see that for solution of this problem it is necessary to define the values of six unknowns variables. To do this, necessary to calculate the numerical characteristics $W_{closed}^{desired}\left(\delta\right)$, for six interpolation nodes. In the result there is a system of six equations with six unknowns.

In paper [2] the solution of such problem is represented. The Newton's Method is used for solving a system of nonlinear equations. But there is complexity. It is consist of the determinant of the Jacobian in this problem has a very small value (about 10^{-26}). When the number of unknown parameters or the computational accuracy of problem is increase, the task goes to the class of ill-posed problems. In this case, there is the need for additional computing power. The method of regularization which was proposed by the Soviet mathematician Tikhonov [3, 4] is solving these problems.

3. The regularization of the Tikhonov

The method of regularization of the Tikhonov [3, 4] is based on using a special addicted priori information about the solution. The concept of regularization amounts to replacing the original ill-posed problem

$$A \cdot y = B \tag{4}$$

by the problem of minimizing the following functions:

$$\Omega(y, \lambda) = \left|A \cdot y - B\right|^2 + \lambda \cdot \left|y - y^0\right|^2. \tag{5}$$

It is the Tikhonov functional.
There λ is the small positive regularization parameter.

As part of linear systems the solution to the problem of minimizing the functional (5) reduces to the solution of a linear system of equations:

$$\left(A^T A + \lambda \cdot E\right) \cdot y = A^T B,\ \lambda > 0.$$

Selection the desired λ depends on the given solution accuracy and stability requirements of computational algorithms.

Conclusion

In the paper the need of using the regularization for synthesis multi-loop control systems is presented. Further work is reduced to the study of possible applications Tikhonov regularization for the synthesis of multi-loop control systems.

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INTEGRAL VARIABLE STRUCTURE CONTROLLER

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Abstract – In this research, we consider the integral variable structure controller. Research includes comparison analysis of control qualities with PID-controller and system robustness analysis.

Now we consider two controller synthesis approaches. Most of industrial processes are controlled by using proportional-integral-derivative (PID) controllers. The popularity of PID controllers can be attributed partly to their good performance in a wide range of operating conditions and partly to their functional simplicity, which allows engineers to operate them in a simple, straightforward manner. To implement such a controller, three parameters must be determined for the given process: proportional gain, integral gain, and derivative gain [1]. Restrictions cannot be taken into account when we choose gain values in the controller. This problem is solved by specialized packages. In the example (fig. 3), the PID-controller was tuned in Check Step Response Characteristics. It is utility of Simulink Library of MATLAB.

Second solution is developed variable structure controller, which based on State Space analysis [2]. In order to get one more state variables we introduce integrator. This controller enables us to consider restrictions on the synthesis stage of control strategy. This is time-optimal system. It is easy to implement this control strategy with computer equipment. Such a control strategy allows us to reduce erasing actuators. But this control strategy is sensitive to variations of system parameters and can lead system to instability.

To achieve effective control strategy in industrial processes are used adaptive systems. These systems are usually based on the adjustment of gain in PID controller. It takes a long time for the selection of gain values by computer. Adaptation of the integral variable structure controller needs less computer calculation time than adaptation of the PID controller.

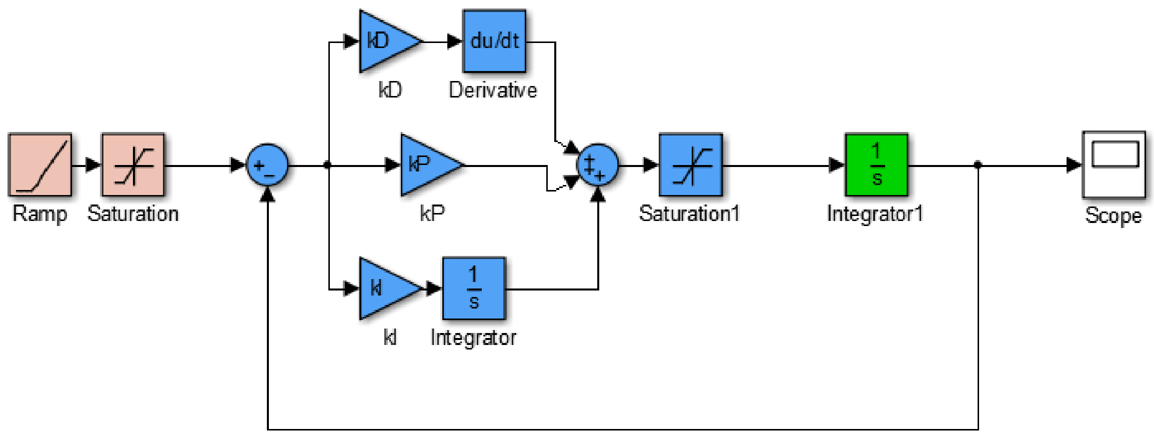

Fig. 1. System with PID controller

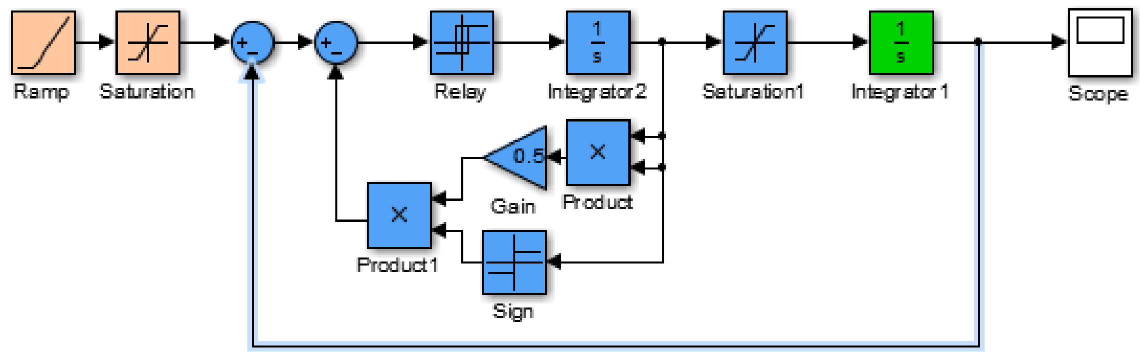

Fig. 2. System with integral variable structure controller

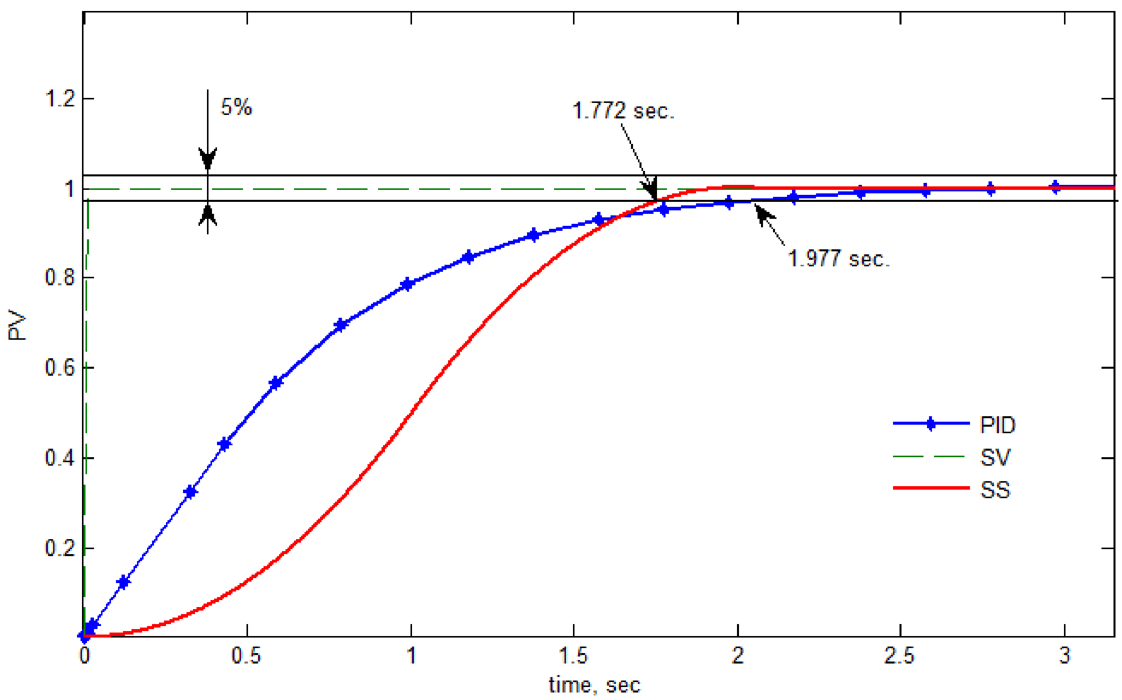

Fig. 3. Step response: PID – system on fig. 1; SS – system on fig. 2

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ADAPTIVE CONTROL SYSTEM OF DISTRIBUTED PARAMETER SYSTEMS

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Аннотация – В теории автоматического управления существует задача управления объектами с распределенными параметрами. Ее важность обусловлена наличием множества реальных объектов, имеющих распределение параметров в своей структуре. Задача осложняется тем, что большинство алгоритмов синтеза регуляторов создано для объектов с сосредоточенными параметрами и учитывает свойства объектов, которые описываются дифференциальными уравнениями в частных производных и иррациональными передаточными функциями. Данную проблему можно решить, используя специальные алгоритмы идентификации, которые будут формировать, необходимые для управления, модели объектов. В данной работе представлен такой вид адаптивных систем управления, который объединяет подходы идентификации систем и метод адаптивного управления на основе модели (MRAC).

In current times there is a problem with concerning distributed parameter systems in control engineering issues. Importance of the problem is caused by controller design goals for industrial plants which have distribution in its parameters. For example, these parameters may vary from temperature of a rod or deflection of a laser's beam [1]. These systems are described by partial-differential equations (PDE) and often have high order partial derivatives. The transfer functions of distributed parameter systems (DPS) are irrational functions in contrast to lumped-parameter systems which are described by rational transfer functions. It brings complexity to controller design issues, because the most part of controller design algorithms relates to rational transfer function descriptions. Irrational transfer functions have infinitely many poles and zeros and it's one of the problems which make analysis much more difficult than in rational transfer functions case. This is why control engineers and researches are using the approximation methods which can help to understand main distributed parameter systems properties and make their analysis simpler. It gives the possibility to develop a controller and get the best performance of control system. This paper presents a kind of adaptive control systems which unite the model reference approach and identification approach.

There is an approach which is based on model reference adaptive control (MRAC) [2]. Short description of this method tells that if there is a model then control system can compare output of a plant with output of the model. The difference between outputs causes tuning of controller's parameters. This tuning improves quality of control and makes conditions for high performance of the process. The image of this adaptive control system is shown on fig. 1.

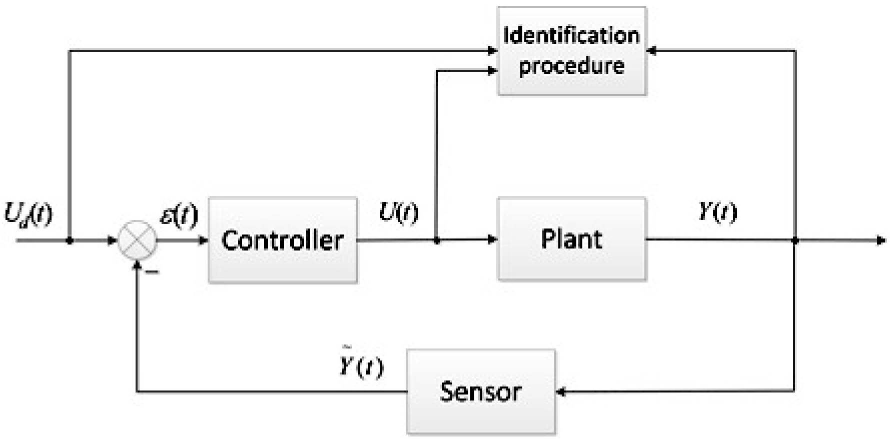

Fig. 1. Control system with identification loop. On this picture:
$U_d(t)$ *– is a desired output;* $\varepsilon(t)$ *– is an error function;* $U(t)$ *– is a control input signal;*
$Y(t)$ *– is a plant's output;* $\tilde{Y}(t)$ *– is a filter's output*

But there is a problem with the model. It is an unusual situation when researches have a mathematical description. Usually there is no model and researches cannot use MRAC approach. Solution for this problem is to use identification loop in structure if control system. It collects experimental data which looks like arrays of inputs and outputs and then use it for obtaining the mathematical model. On fig. 2 there is the image of such kind of systems. Unfortunately, in common case, it is only one part of solution. When researches work with distributed parameter system they have to consider this. For this purpose, in control system's structure summation element with quantity coefficient is placed. This element is used for collecting outputs of distributed parameter system and then calculating an average output. This average output is used for identification purpose. A result of identification purpose is a mathematical description of a plant in terms of rational transfer function. This transfer function helps to use controller design technics which are created for lumped parameter system.

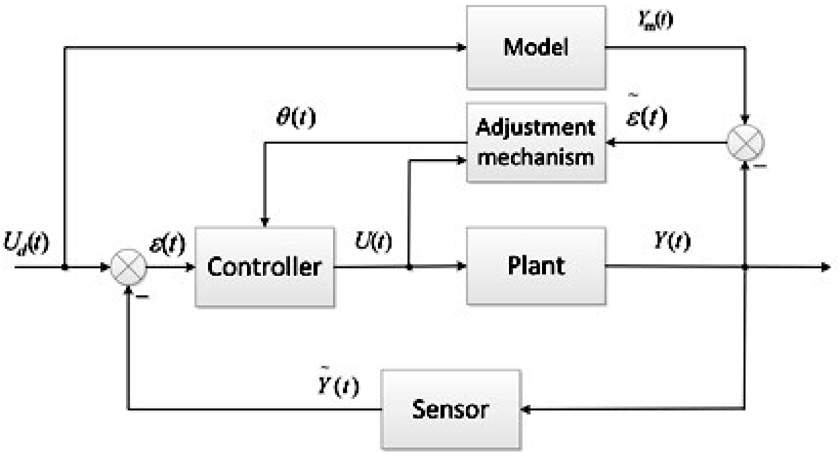

Fig. 2. Model reference adaptive control system. On this picture additional elements are illustrated: $Y_m(t)$ – is an output of the model; $\tilde{\varepsilon}(t)$ – is an additional error function; $\theta(t)$ – is a vector of controller's parameters

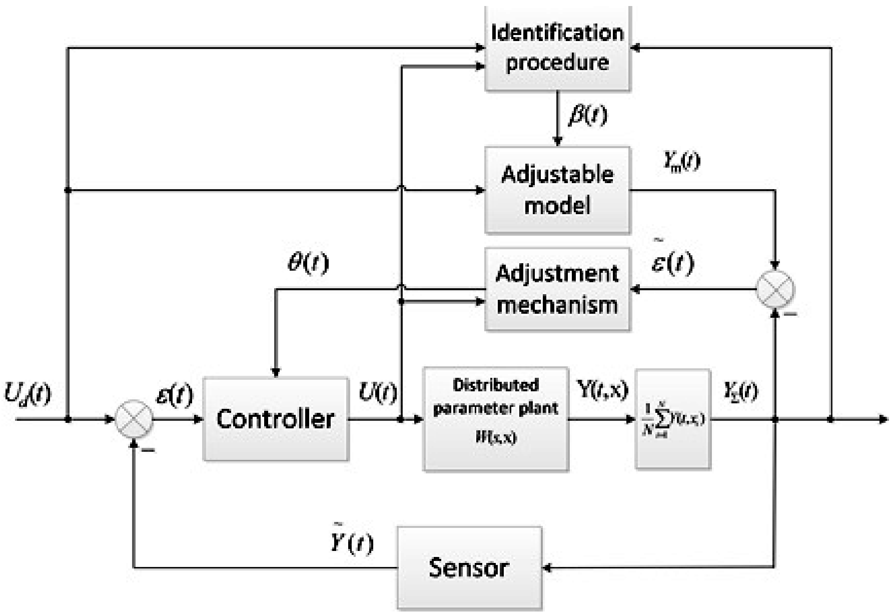

Fig. 3. Model reference adaptive control system with identification loop. On this picture additional elements are illustrated: $Y_\Sigma(t)$ – is an approximated output of the plant; $Y(t, x)$ – is a vector of plant's output signals; $\beta(t)$ – is a vector of adjustable model's parameters

Conclusions

In this paper short description of adaptive control system with MRAC approach and identification loop is presented. This kind of system brings a new way of control for distributed parameter system and gives the possibility to improve control quality.

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THE OPT-ACOUSTIC DEVICE FOR VARIABILITY MONITORING AND DIAGNOCTICS OF EQUIPMENT CONDITION

Evgeny A. Rybakov, Dmitry P. Starikov, Evgeny I. Gromakov

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Аннотация – Цель данной работы: создание программно-аппаратного комплекса для ранней диагностики и точной локализации неисправности в сложной геометрии нефтегазоперекачивающего оборудования, а именно акустическая камера (АК).

Introduction

Acoustic camera – is the camera with sensors (microphones). The sound reaches each of the microphones for different times due to different distances from the source to each of the microphones.

Suppose camera is aimed at the geometrically complex, massive object, such as a main pump (see fig. 1). It is necessary to consider the projection onto the plane of each distance between camera and microphones. Each of the four microphones simultaneously captures the sounds coming. If there is a sharp change in frequency that does not match the technological process (crack, etc.), the camera fixes it and calculates the exact location in the plane of the incorrect sound [1].

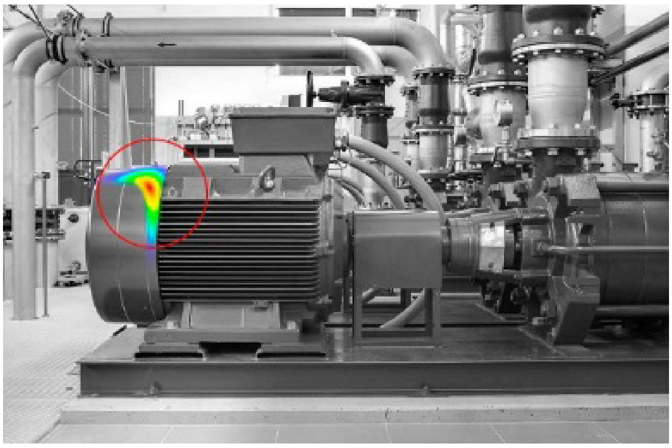

Fig. 1. Frame

Model and description

The calculation is performed using the equation of the circle where the only unknown variable is z – time of occurrence of the event to fix this event nearest sensor.

In the end program is formed of the equation (1) where α – the distance between the center coordinates and microphones, Δz_i – phase difference [2].

$$
\begin{aligned}
&z^2 = (x - \alpha)^2 + y^2 \\
&(z + \Delta z_1)^2 = x^2 + (y + \alpha)^2 \\
&(z + \Delta z_1 + \Delta z_2)^2 = x^2 + (y - \alpha)^2 \\
&(z + \Delta z_1 + \Delta z_2 + \Delta z_3)^2 = (x + \alpha)^2 + y^2
\end{aligned}
$$

The system of equations (1) is possible to express z (fig. 2), and then build from each center, circle; where the common point of intersection is the localization of noise, we are interested. Then the program automatically creates a gradient of prevalence of specific noise and scale the result, under the format of the camera window.
The system is based on two programmable controllers atMega, different bit [3].

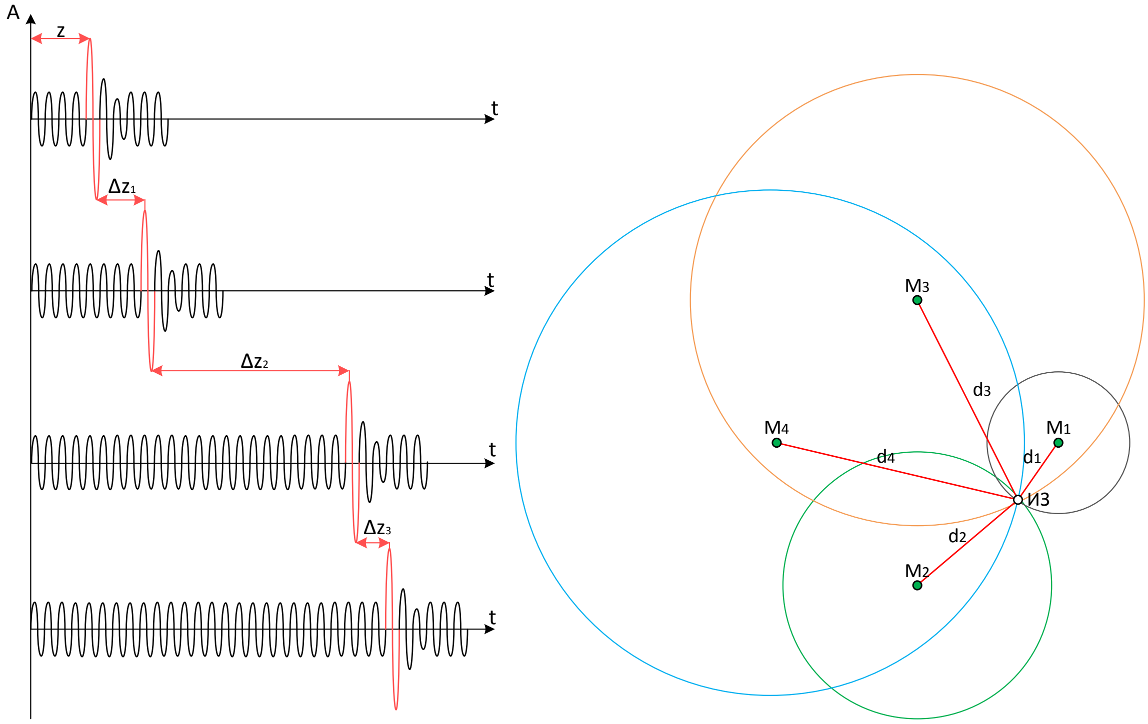

Fig. 2. Math description

Conclusion

Advantages include: the exact location of faults and reduce the cost of equipment. So there are disadvantages:

- Low accuracy of localization:
  Eliminated by increasing the distance between the microphones in the plane of the device and an increase in their numbers (8, 16, 32) [4];
- Low frequency range:
  Eliminated by increasing the quality microphones.

The accuracy of the prototype is 1 mm at a distance of 1.5 m. This indicator is easily increased by increasing the distance between the microphones.

Acoustic camera can be successfully implemented for the diagnosis and alarm pumps, electric compressors. The prospect of this decision is obvious in view of economic and technological factors.

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APPLICATION OF COHERENCE ANALYSIS FOR IMPROVING INFORMATIVITY OF TIME-FREQUENCY CORRELATION FUNCTION

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Аннотация – Предложен способ повышения информативности частотно-временной корреляционной функции, при оценке запаздывания сигнала, за счет привлечения информации о когерентности исследуемых сигналов измерительных каналов.

Актуальной задачей обработки сигналов в современном неразрушающем контроле, в частности при обследовании трубопроводов на предмет обнаружения утечек, является оценка запаздывания сигнала. В настоящее время разработаны различные подходы и методы решения данной задачи общей чертой которых является использование аппарата корреляционного анализа [1] в сочетании с предобработкой анализируемых данных.

Перспективной группой методов исследования сигналов, в контексте заявленной задачи, представляются частотно-временные методы, отличительной особенностью которых является построение зависимостей некоторых информативных параметров сигнала от времени и частоты. В частности, в [2] предложено построение и визуализация частотно-временного кросс-спектра, позволяющего производить оценку динамики возникновения импульсного сигнала. В [3] предложен частотно-временной корреляционный метод анализа, который может быть применен в качестве альтернативы традиционному методу корреляционного анализа, для достижения большей наглядности визуально представленных результатов и лучшей помехоустойчивости.

Однако частотно-временной корреляционный подход не лишен недостатков, в числе которых является необходимость привлечения сторонних методов поиска частотной полосы локализации неслучайного сигнала для повышения точности и надёжности анализа, при решении сложных задач. Наиболее простым из сторонних методов обнаружения спектра полезного сигнала является когерентный анализ [4]. Основным выражением когерентного анализа является

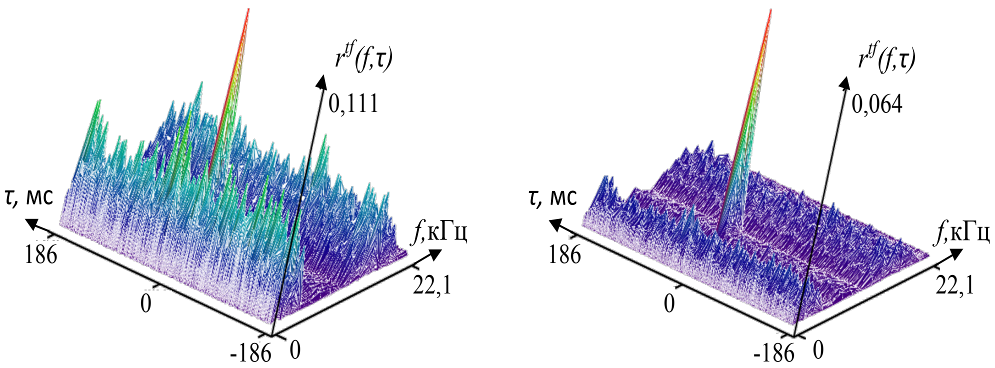
$$\gamma^2(k) = \frac{\left|\sum_{q=0}^{Q-1} P_{ABq}(k)\right|^2}{\sum_{q=0}^{Q-1} P_{AAq}(k) \sum_{q=0}^{Q-1} P_{BBq}(k)},$$

где $\gamma^2(k)$ – квадрат функции когерентности; Q – число интервалов разбиения; $P_{AB}(k)$, $P_{AA}(k)$, $P_{BB}(k)$ – соответственно взаимный мгновенный спектр и собственные мгновенные спектры сигналов. Квадрат функции когерентности принимает значения в диапазоне [0, 1] и отражает степень линейной взаимосвязи гармонических компонент анализируемых сигналов [4], что качественно дополняет корреляционный анализ.

Для интеграции частотно-временного и когерентного способов анализа предлагается осуществлять домножение частотно-временной корреляционной функции на функцию когерентности, тем самым дополнительно выделяя на поверхности частотный интервал, содержащий связанные во времени гармонические компоненты сигналов:

$$\dot{r}^{tf}(m, k) = \gamma_m \cdot r^{tf}(m, k),$$

где $r^{tf}(m, k)$ – массив отсчетов частотно-временной корреляционной функции; γ_m – средневзвешенное значение функции когерентности на -ом частотном интервале; $\dot{r}^{tf}(m, k)$ – массив отсчетов модифицированной частотно-временной корреляционной функции [5], учитывающей информацию о когерентности сигналов. На рис. 1, для сравнения, приведены графики обычной и модифицированной частотно-временных корреляционных функций, рассчитанных по идентичному набору входных данных.



а *б*

Рис. 1. Графики частотно-временных корреляционных функций:
а – обычной; б – модифицированной

Несмотря на то, что на обоих графиках, представленных на рисунке, корреляционный пик отчётливо различим, заметно, что на правом графике уровень шумов существенно ниже, что свидетельствует об увеличении эффективности частотно-временного корреляционного метода.

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ROBOTIC ARM’S EXECUTIVE SYSTEM PARAMETERS DEFINING DURING FORCED MOTION

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Аннотация – Показано решение задачи идентификации параметров соединенного с двигателем двухзвенного робототехнического манипулятора, для чего использовались относительные углы поворота звеньев и значение движущего момента на оси.

The problem of the two linked robotic manipulator’s [1] executive subsystem parameters determining is much complicated by second link’s impact to the motions’ law. But the solutions like [2] are quite difficult, so there is a need to find simpler ways of solving this task.

During the forced motion, the manipulator's operator-block diagram was converted to the form shown in fig. 1. It was obtained from the standard block diagram of robot's electromechanical executive subsystem [3]:

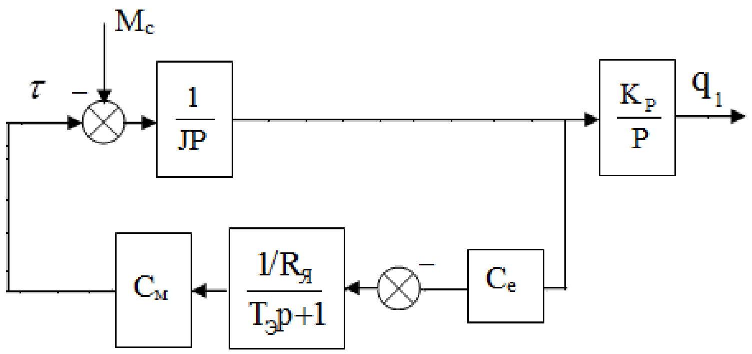

Fig. 1. Executive system's scheme from input τ and output q_1*:*
τ – the motor's torque, q_1 *– relative first link's angle,* $R_я$ *– the armature resistance,* $T_э$ *– electromagnetic constant;* c_e*,* $c_м$ *– constructive motor's parameters; J – inertia moment on a motor's axle;* k_p *– gear's transfer coefficient;* M_c *– modulus of resistance*

The τ signal is considered as input signal for fig. 1 system and q_1, q_2 (relative second link's angle) are two output signals (fig. 2).

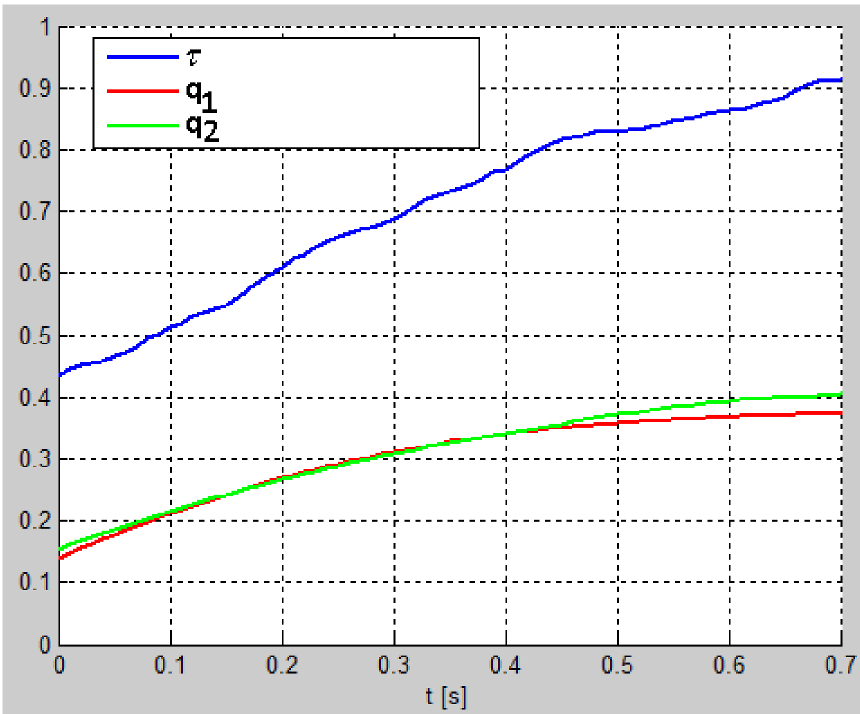

Fig. 2. Input and output signals

During the forced motion the gravitation moment M_c also influences [4]. The angular motion's resulting equation can be shown in form of $q_1 = W_{\theta\tau}(p)\tau + W_{\theta M_c}(p) M_c$.

During the forced motion an identification is implemented using $W(p)\big|_{p=0}$ [5], and then the $\frac{K_p}{p}$ multiplier can be used as K_p, because the total gravitation moment M_c has greater impact on the motion's law (fig. 2). Then the transfer functions change to coefficients: $W_{\theta\tau}(p) = \frac{R_я K_p}{C_e C_M}$, $W_{\theta M_c}(p) = -\frac{R_я K_p}{C_e C_M}$, so $q_1 = \frac{R_я K_p}{C_e C_M}\tau - \frac{R_я K_p}{C_e C_M} M_c$. However, the work [4] says, that M_c can be shown in form of $M_c = k_2 \cdot \sin(q_1) + k_3 \cdot \sin(q_2)$, so

$$q_1 = \frac{R_я K_p}{C_e C_M}\tau - \frac{R_я K_p}{C_e C_M} \cdot k_2 \cdot \sin(q_1) - \frac{R_я K_p}{C_e C_M} \cdot k_3 \cdot \sin(q_2).$$

And solving this task using the method of least, we get a model: $q_1 = 3.8477 \cdot 10^{-4}\tau - 0.9379 \cdot \sin(q_1) - 0.0776 \cdot \sin(q_2)$, which has the absolute error $\Delta(t) = |q_{1m}(t) - q_1(t)|$ as in fig. 3.

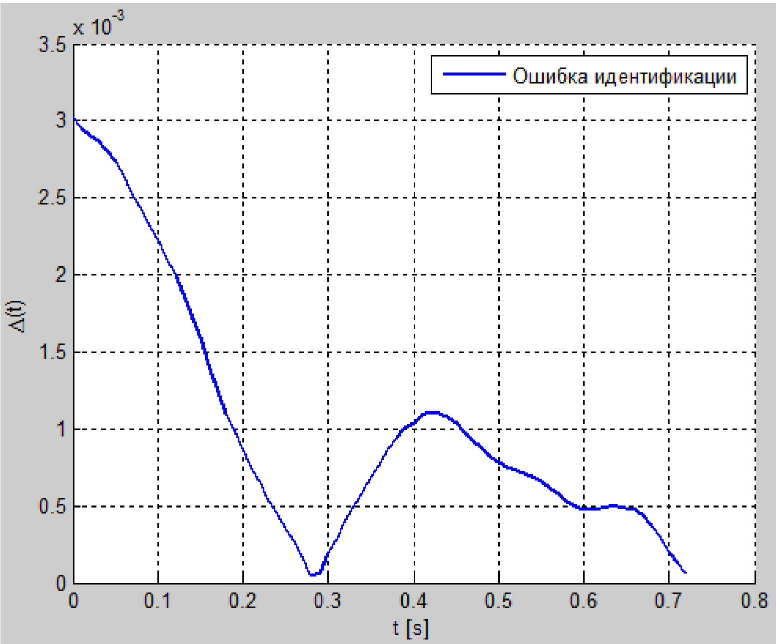

Fig. 3. Identification error in form of absolute error

As a conclusion, the model is computed. So, the next step is to develop control system, which can make manipulator's links move the fixed trajectory. It can be done by adding PID-regulators to the fig. 1 circuit.

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GUI MOBILE DEVICE – IDENTIFIER OF CONTROL OBJECTS

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Abstract – The authors consider creation of convenient and functional graphical user interface for the identifier of control objects on the basis programmable logic controllers of two types.

Introduction

When you configure automatic control systems, the identification of control objects (OC) is very important. The identification process provides a mathematical model of control objects that in the future will provide the coefficients for the accurating configuration of regulators. In this connection was established mobile device management object identifier [1, 4]. To ensure fast and convenient use of the identifier must be simple and intuitive human-machine interface. In modern society, the most widely used graphics device to work at work and at home is the touchpad. Thus parts of the cell identifier consists are the touch panel, controller and I / O modules. The graphical interface of the touch panel must be interactive, correct and understandable by specialists.

Creating the interface

During the development of the GUI created two versions of identifiers.

In a first version, as a programmable logic controller (PLC) is used OWEN PLC 160 and graphic panel – OWEN SP270, as well as any connected modules: analog input and discrete input-output. Programming the controller, a special programming environment Codesys 2.3, and for programming the operator panel is used configuration program SP200, which is supplied with the panel. Creating a graphical user interface revealed that the process of displaying information requires a large amount of graphics memory and performance, for the dynamic display. Therefore, it was decided to choose a more efficient industrial logic controller, as well as for ease of compiling and debugging, combined with the touchpad.

The second option is a controller SPK207 having more speed graphics system and allows you to display more information about the type of control signal and connected properly. SPK207 is more convenient programming environment, combined with graphic elements, thus reducing the amount of work performed during the configuration and programming of the identifier. SPK 207 has a larger number of interfaces (Ethernet, RS-232, RS-232 \ RS-485, USB) to connect to a variety of signal sources, as well as slots for connecting storage devices (USB Flash, SD card). Combining the functions of the PLC and the operator allows, firstly, to reduce the overall cost of ICS, and secondly, to save space when placing the PLC into a box. Increased number of I / O by connecting external modules according to any of the built-in interfaces. SPK 207 management is carried out using the touch screen and the extra buttons with LED located on the front of the controller.When device is connected, dialog of selecting functions is appeared: «CHOOSE MODULE», «CHOOSE CONNECTION», change language interface «LANGUAGE»: English or Russian, as well as help page for «HELP» (fig. 1). The next step is used to select the module, which will be connected to an external signal source (sensors).

After you select the module, determine which inputs were connected to sensor or actuator (fig. 3). When you press the desired input, a dialog box appears to confirm or cancel the selection. After connecting to the corresponding input, button move to the next menu screen becomes active to complete the identification phase of the signal.

Fig. 1. The initial window of device

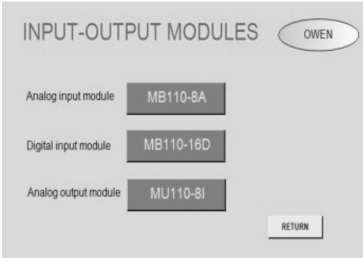

Fig. 2. Selection window of I \ O modules

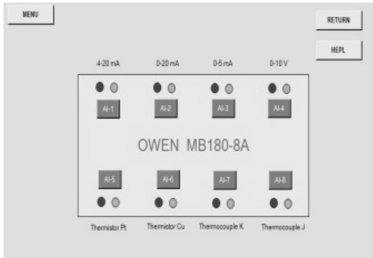

Fig. 3. The window of analog input modules

Conclusion

A graphic interface of the mobile device identifier control objects on the basis of industrial controllers of «OWEN» SPK207 was created. Currently further work connected with correcting display of obtained information, as well as the most accurate charts and graphs.

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GPU-ACCELERATED MOBILE ROBOT LOCALIZATION

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Introduction

The problem of localization is one of the most important problems that has to be solved for autonomous robot control. One of the most effective methods of robot localization is particle – based Monte – Carlo method. Given the map of the environment, this algorithm estimates the position and orientation of robot as it moves and senses the environment. In Monte – Carlo method system state is represented by set of particles. Each particle is a data object containing one of the hypothetical robot states from the distribution and a «weight» value. To maintain an accurate representation of the state distribution, we must have a large number of particles, which makes the particle filter computationally intensive. However, the hardest steps in the particle filter are done independently on each particle, so it is inherently suitable for parallel processing on graphical processing unit (GPU). CUDA [1] is a parallel computing platform running on NVIDIA GPUs It is one of the popular GPGPU (General-Purpose computing on GPU) platforms.

Monte-Carlo localization

The idea of Monte – Carlo localization is representation of possible robot states by set of particles. These particles can be seen as virtual copies of robot's existence. Particles move simultaneously with robot according to robot's motion model and have several sensor beams representing robot's sensor model.

Our robot operates in the laboratory of robotics and turns with differential steering, so its state includes three variables – x, y coordinates for robot's location and θ – yaw angle for robot's orientation.

There are main steps of the algorithm are presented below:

1. Generate a set of particle and initialize them with random positions and weights.
2. Apply robot's motion model to particles to predict the next robot's state.
3. Sense the environment and compare actual measurements with predicted ones.

4. Compute particle weights according on how well each particle predicted the actual robot's state.
5. Resample the distribution. Probability of choosing each particle is proportional to its weight value.
6. Back to step 2.

Results

On fig. 1, you can see comparison of algorithm implementations using CPU and GPU. We tested a plenty of particle numbers in order to collect an accurate statistics.

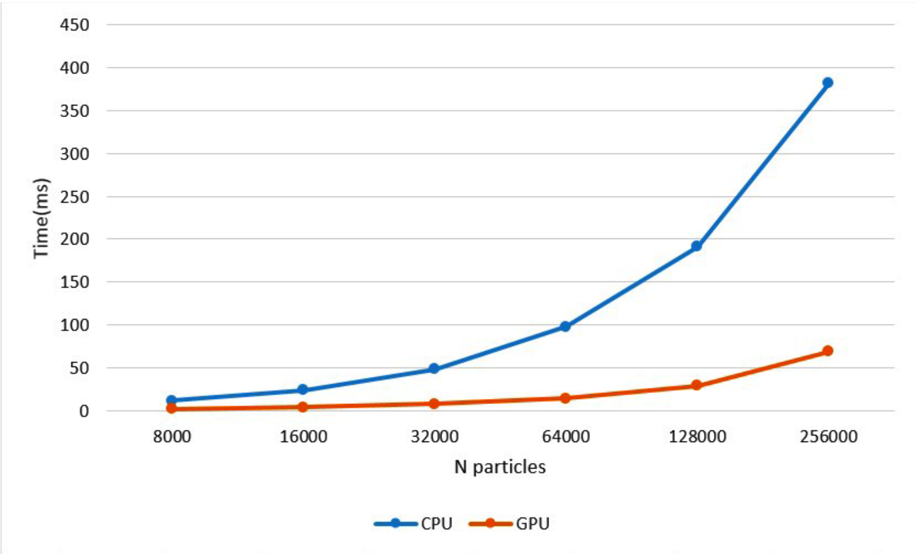

Fig. 1. Performance tests

We can see that using CUDA in Monte – Carlo localization implementation gives us a great increase in performance. As it was predicted, the weight calculation step is the most time – consuming step in the algorithm. After porting it onto CUDA, we obtained approximately 15 times speed – up. Algorithm was tested in specially created simulator. Now it is ready for using on real hardware.

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LASER TECHNOLOGIES BASED ON MULTIWAVELENGTH NANOSECOND LASERS

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Аннотация – Представлен обзор результатов исследования лазера на парах стронция, которые показали, что в этом лазере возможно получение высоких энергетических (до 22 Вт) и частотных (≥ 1 МГц) характеристик. Подобные лазерные источники могут успешно применяться в микрообработке стекла, для резонансной абляции полимеров и биотканей, а также в дистанционном газоанализе.

Постановка задачи

Лазер на парах стронция (ЛПС) является эффективным источником лазерного излучения в ИК диапазоне на самоограниченных переходах с $\lambda = 6{,}456$ мкм; $\lambda \sim 3$ мкм ($\lambda = 2{,}60$; 2,69; 2,92; 3,01 и 3,06 мкм) SrI и $\lambda \sim 1$ мкм ($\lambda = 1{,}091$, 1,033 мкм) SrII. Как показывает анализ, длины волн излучения ЛПС входят в полосы поглощения полимеров и биотканей. Высокий коэффициент поглощения лазерного излучения на этих длинах волн обеспечивает эффективную абляцию, что позволяет найти лазеру применения в медицине, а также для обработки полимеров.

К настоящему времени в ЛПС реализована средняя мощность генерации ~ 13,5 Вт в режиме – «генератор», 22 Вт в режиме – «генератор-усилитель», при чем энергосъем в лазере растет пропорционально объему активной среды. Наряду с линиями генерации на самоограниченных переходах атома и иона стронция получена генерация на самоограниченном переходе (2^1P_1–2^1S_0) атома гелия $\lambda = 2058$ нм и переходах (2s–2p) атома неона в смеси (He + Ne + Sr). Реализован ионизационно-рекомбинационный режим работы ЛПС, при котором наряду с линиями генерации на самоограниченных переходах атома и иона стронция, реализована генерация на линии $\lambda = 430$ нм SrII [2]. Экспериментально достигнута частота следования импульсов (ЧСИ) генерации ~ 830 кГц [2]. При этом результаты численного моделирования [1] показали, что предельная ЧСИ генерации в лазере на парах стронция может составлять ~ 1 МГц.

Применение лазера на парах стронция в медицине основано на эффекте абляции – удалении биоткани под действием лазерного излучения. Было установлено, что длина волны 6,45 мкм одной из оптимальных длин волн для рассечения биоткани. При воздействии на костные ткани лазерного излучения на данной длине волны были получены разрезы длиной 1…3 мм. Ширина резов составила 100…350 мкм при ширине зоны термического повреждения 10 мкм и более [3].

Следующей технологией, где успешно используется лазер на парах стронция, является управляемый термораскол стекла [4]. Сущность метода заключается в создании объемного термического напряжения хрупкого материала лазерным излучением, как правило, имеющим форму эллиптического пучка, вытянутого вдоль направления движения с последующим охлаждением зоны нагрева с помощью хладагента, например, воздушно-водяной струи. При подаче хладагента вслед за лазерным пучком на фронте кипения происходит резкое локальное охлаждение поверхности материала по линии реза. Создаваемый градиент температур обуславливает возникновение в поверхностных слоях материала напряжение растяжений, которые обеспечивают образование и распространение трещины определенной глубины.

К преимуществам указанного метода резки следует отнести большую скорость разделения; высокую точность при размерной обработке; низкую энергоемкость процесса обработки; безотходность процесса разделения; высокое качество поверхности разделяемых изделий.

Таким образом, не смотря на достаточно большие габариты по сравнению с полупроводниковыми системами лазер на парах стронция нашел свое применение в медицине и промышленных технологиях.

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