IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 14, Issue 2 Ser. I (Mar. – Apr. 2019), PP 44-48
www.iosrjournals.org

Application of Robust control Algorithm for The Motion System of Almega 16 Manipulators

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Abstract: *This paper presents an application of robust control algorithm in joint space for the motion system of Almega16 manipulator. The control method has strengths that minimize calculations on-line and stable when added to the external noise, do not need to know before the parameters and dynamics of any guarantee asymptotic stability. The results from Matlab - Simmulink simulations and experiments show that the motion system of Robot Almega16 satisfies the requirement of a control system: the errors of rotating joints and the steady state cartesian position quickly converge to zero within a short transient time, so that closed-loop system is stable based on Lyapunov method.*

Keywords: *Application of robust, Almega16 manipulator*

Date of Submission: 03-04-2019 Date of acceptance: 18-04-2019

I. Problem statement

Industrial Robots - Robot Almega16 is a highly nonlinear object with many uncertain parameters that are affected by the joints motion which causes the orbital distortion. Therefore, it is always international and domestic scientists' interest to improve quality of precise trajectory motion control of industrial robots are always interested many scientists in and outside the country. Hence, the article mentioned about the control of motion of the industrial robot as well as some proposals to improve the quality of motion of industrial robots in the joint space.

II. Application of robust control algorithm in industrial robot motion

A stable controller defines a sliding surface and steers the system toward the sliding surface, then the system slips on the surface and remains stable even under the influence of noise. This eliminates the nonlinear effect of joints by applying the system to the sliding surface. This control rule is also based on the Lyapunov stability standard.

Derived from the dynamic equation written in the form:

$$\tau = M(q)\ddot{q} + C(q,\dot{q})\dot{q} + G(q) \tag{1}$$

Sustainable control law is included as follows:

$$\tau_{dk} = \hat{M}(q)\dot{v} + \hat{C}(q,\dot{q})v + \hat{G}(q) + K\,\mathrm{sgn}(r) \tag{2}$$

In particular:

$\hat{M}(q), \hat{C}(q,\dot{q}), \hat{G}(q)$: estimated components of M(q), $C(q,\dot{q})$, G(q)

$v = \dot{q}_d + \Lambda(q_d - q) = \dot{q}_d + \Lambda e$

Λ : is the cross matrix, positive determinant

$r = v - \dot{q}$

K: "damping", cross matrix, positive determinant

$\mathrm{sgn}(r) = [\mathrm{sgn}(r_1), \mathrm{sgn}(r_2), ..., \mathrm{sgn}(r_n)]^T$

$$\mathrm{sgn}(r_i) = \begin{cases} +1 & \text{if } r_i > 0 \\ -1 & \text{if } r_i < 0 \end{cases}$$

$$\tau_i = \begin{cases} \tau_i^+ & \text{if } r_i > 0 \\ \tau_i^- & \text{if } r_i < 0 \end{cases}$$

Select positive Lyapunov:

$$V = \frac{1}{2} r^T M(q) r \Rightarrow \quad \dot{V} = r^T M(q)\dot{r} + \frac{1}{2} r^T \dot{M}(q) r \tag{3}$$

Combine (3.55) and (3.56) we got the robot's sealed dynamic equation as follows:

$$M(q)\ddot{q} + C(q,\dot{q})\dot{q} + G(q) = \hat{M}(q)\dot{v} + \hat{C}(q,\dot{q})v + \hat{G}(q) + K\,\mathrm{sgn}(r) \tag{4}$$

Select $\begin{cases} r = v - \dot{q} \\ \dot{r} = \dot{v} - \ddot{q} \end{cases}$ and $\begin{cases} \tilde{M} = M - \hat{M} \\ \tilde{C} = C - \hat{C} \\ \tilde{G} = G - \hat{G} \end{cases}$

Replace in the equation (3.59) we got:

$$\begin{aligned} M\dot{r} + Cr + K\,\mathrm{sgn}(r) &= \tilde{M}\dot{v} + \tilde{C}v + \tilde{G} \\ \Rightarrow M\dot{r} &= \tilde{M}\dot{v} + \tilde{C}v + \tilde{G} - Cr - K\,\mathrm{sgn}(r) \end{aligned} \tag{5}$$

As $S = C(q,\dot{q}) - \frac{1}{2}\dot{M}(q)$ is the opposite of the matrix so $C(q,\dot{q}) - \frac{1}{2}\dot{M}(q) = 0$

Combined with (5), (6) we got:

$$\dot{V} = r^T(\tilde{M}\dot{v} + \tilde{C}v + \tilde{G}) - \sum_{i=1}^{n} k_i |r|_i \tag{6}$$

With $\dot{V} \le 0$, we have $k_i \ge \left|[\tilde{M}\dot{v} + \tilde{C}v + \tilde{G}]_i + \eta_i\right|$ với $\eta_i > 0$

Then

$$\dot{V} \le -\sum_{i=1}^{n} \eta_i |r_i| < 0 \tag{7}$$

Therefore the system will be stable according to the Lyapunov standard.

Advantages and disadvantages of sustainable control methods:

Advantages: This controller, like the adaptive controller Li-Slotine [5], does not need the exact dynamics parameters of the robot, but it still stabilizes the system, ensuring the deviation between the set values and the real value drops to 0 quickly, stabilizing the system even with interfering effects.

Disadvantages: The identification of the envelope, gender in which the system is stable is very
 Difficulties are not always identified, even undetermined. To limit this disadvantage, it is best to combine the adaptive controller as the adaptive controller is able to determine the change of the zone so that the system can be stabilized.

1) Structural diagram of the VSC Sustainable Controller

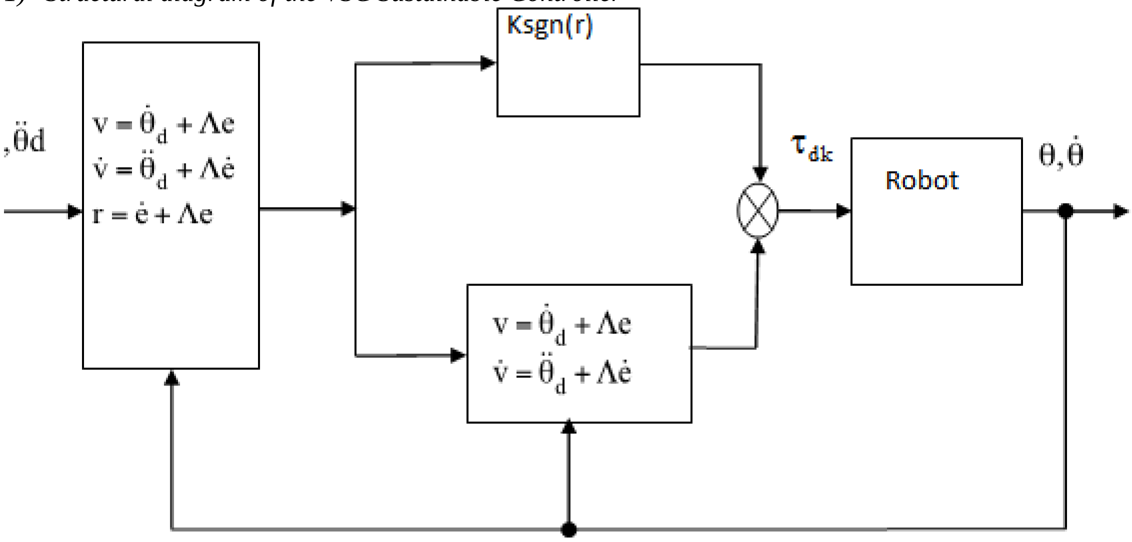

Figure 1. Structural diagram of the VSC Sustainable Controller.

III. Applications for sustainable controls in Almega robot 16

For the adaptive control algorithm we use the equation of the hand-held Almega 16 with 3 joints (joint 1, joint 2, joint 3) established in [6].

Parameters of the Almega 16 Robot: Because the total mass of the Almega 16 is 250 kg and based on the data of 3 joints, the basic parameters of the three joints are calculated as follows:

Parametric calculation and system survey using Matlab / Simulink and Matlab / Simechanic software, with parameter table of durable controller (table 3.1) for the results shown (Figure 3 ...).

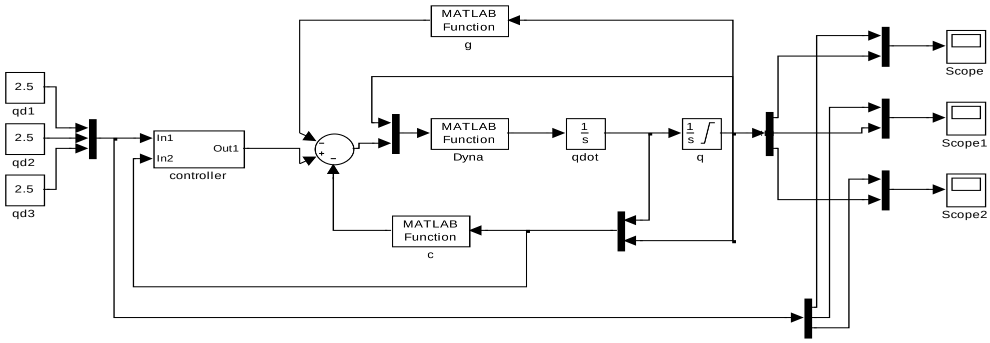

Figure 2. Simulink simulates the law of sustainability.

In particular: g, c, Dyna is a matrix function G, C, and function for calculating

In1, In2: are values that set matched variables and actual values of matched variables

con_in: is a control rule function

controller: is a stable controller structured as shown in Figure 3.15

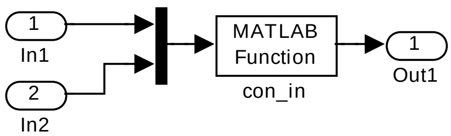

Figure 3. Stable controller.

Table 3. Parameter of controller.

Abbreviation	Parameter	Parameter of joints
K	Damping	$K_1 = 3,\ K_2 = 3,\ K_3 = 3$
q_d	Stated value	$q_{d_1} = 2.5(rad), q_{d_2} = 2.5(rad), q_{d_3} = 2.5(rad)$
Γ	Positive cross matrix	$\lambda_1 = 50, \lambda_2 = 50, \lambda_3 = 50$

Simulation result:

a**. Simulation result in absence of interference.**

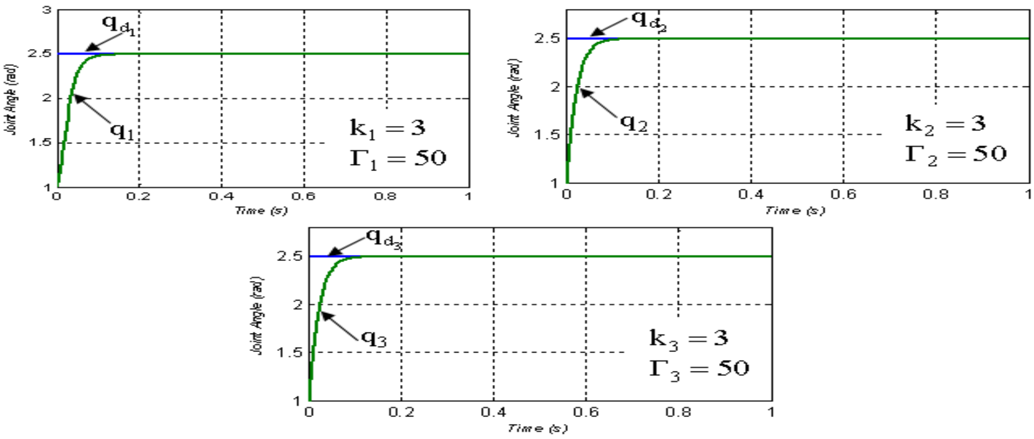

Figure 4. Three-corner misalignment without interference.

b. Simulation results in absence of small interference

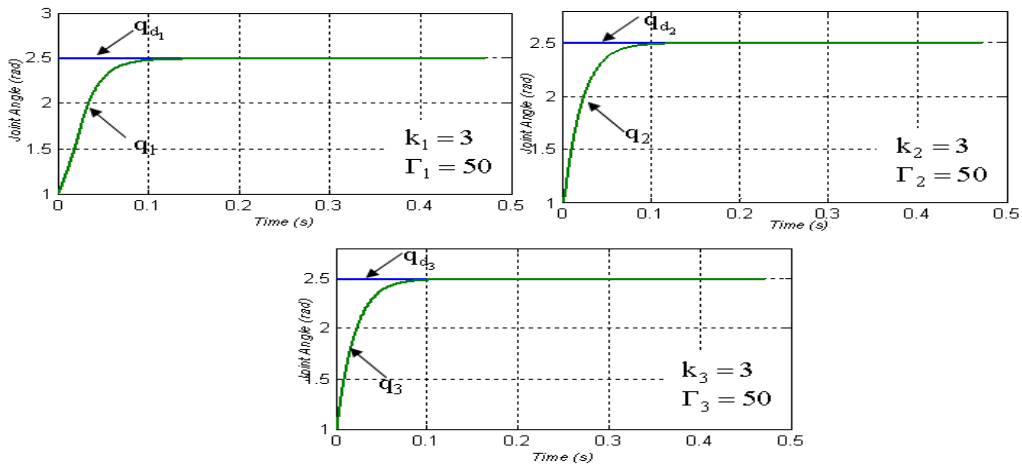

Figure 5. Three-corner misalignment with small interference.

c. The simulation results with great interference

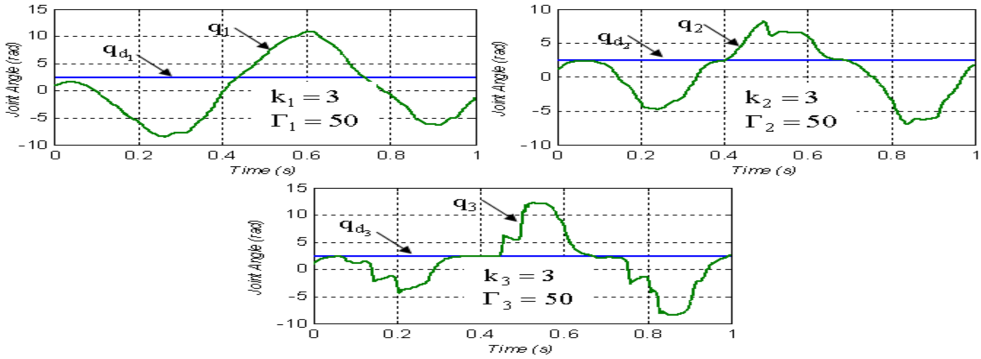

Figure 6. Three-corner misalignment with great interference.

Comment: From the simulation results of the above durable control method with the Almega 16 robot, (Fig. 4, Fig. 5, Fig. 6) shows that this controller is only capable of stabilizing the system in one zone. In this zone, without interference, the system is stable; the gap between the set value and the real value does not go to 0, and no oscillation. Outside of that boundary, stable controllers are unstable systems, deviations do not go to 0 but oscillate is very strong. In the case of great interference, the simulation does not have any parameters that can make the system stable. This leads to the difficulty of applying to the real robot system because the robot works with noisy interference and this undetermined noise can lead to certain outages that cause instability in the system.Therefore, in practice, the controller is combined or used.

IV. Conclusion

The research addressed the problem of re-proofing the sustainable control algorithm by simulating the Almega 16 robot in the articulated space which ensures that the quality of the trajectory does not depend on any constant parameter The model of dynamic model and the effect of the inter-channel components between the axes. Sustainable control law addresses this problem by identifying the zone which is stable without being affected by any interference. Particularly, the task of a durable controller is to identify a sliding surface and steering the system to that sliding surface, then the system will "slide" on the surface and will remain stable even under the impact of noise. This eliminates the nonlinear effect of joints by applying the system to the sliding surface. This control rule is also based on the Lyapunov stability standard. This can be used to design and apply sustainable control algorithms suitable for multi-level TMCN motion systems.

References

[1]. Nguyen Manh Tien, Controlling industrial robots, Science and Technology Publishing House, 2007.
[2]. Nguyen Thien Phuc, Industrial Robot, Science and Technology Publishing House, 2004.
[3]. Nguyen Phung Quang, MATLAB & SIMULINK for automatic control engineer, Science and Technology Publishing House, 2006.
[4]. Neil Munro, Frank L. Lewis, Robot Manipulator Control Theory and Practice, Marcel Dekker 2004.
[5]. John J. Craig, Introduction to Robotics: Mechanics and Control, 1995. Mark W. Spong, F. L. Lewis, C. T. Bdallah, Robot Control: Dynamic, Motion Planning and Analysis, 1992.
[6]. Ha.V.Th: A number of control solutions to improve the quality of industrial hand movements, PhD thesis, 2012.

IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) is UGC approved Journal with Sl. No. 4198, Journal no. 45125.

Duc Thang Doan. " Application of Robust control Algorithm for The Motion System of Almega 16 Manipulators." IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) 14.2 (2019): 44-48.