Verification of the Mathematical Model of the Robot Scara by the Implementation of Virtual Reality

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Abstract: **Articulated robots, with applications ranging from the simplest to the most complex, with its importance and popularity, especially with the reduction of costs and further studies on the feasibility of developing a complete mathematical model for the arm industrial selective compliance robotic Here we present the servo-motor dynamics and dynamics simulation, as well as the inverse kinematic analytical problem. (AIKP) and direct kinematic solution with DH parameters, the robot arm is built for manipulation trajectories, etc. The model of virtual reality 3D (VR) realizing, it builds and receives commands via a link Matlab / Simulink, for the design to simulate, on the matlab R2013 b.The analytic version. IKP solution and real law modeling, considerations are taken into account here, the integrated approach improves system performance, cost efficiency, efficiency and high performance. The effectiveness of the method is proven, gives a better answer and better setting. This is an advantage for the industry and a real-time application is possible via interface cards.**

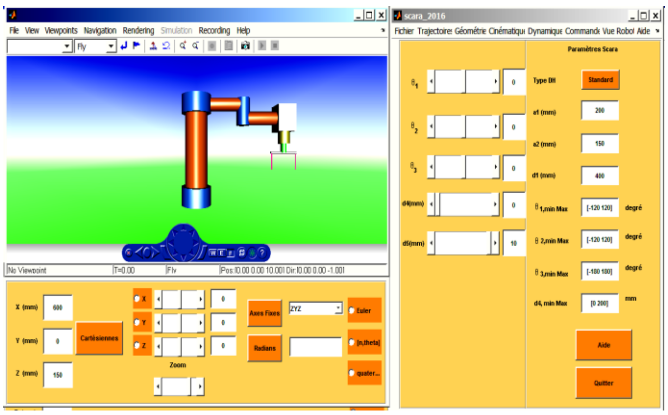
Key-Words: **SCARA robot, mathematical, modeling analytical, inverse kinematic problem (AIKP), DC servo motor, Matlab /Simulink**

I INTRODUCTION

Robots today feature prominently in human. Life, ranging from toys to office use and from the industrial to the ultra-sophisticated, the use of robots, its design, modeling, and control, from the science of robotics, which feature widely in manufacturing processes. Industrial robot have manipulators whose joints could be rectangular ,spherical ,revolute ,or horizontal ,A horizontal revolute robot ,the selective compliance articulated robot arm (SCARA) ,has four degrees of freedom (DOF) ,with two or three horizontal servo-controlled joints for shoulder,elbow,and wrist real robot, robotics is the aim ,but simulation prior to investigation with real robots often are useful ; simulation is easier to set up quickly ,A simulated robotic setup costs less than do real robots and real –world setups ,and designs can be better explored .simulation often is faster than the real movement ,and parameters are visible on screen[1-10].Advanced stages of design demand real-time simulation, to verify the final design before costly and time consuming prototyping begins .Higher accuracy and more computationally effective manipulator dynamics are being increasingly demanded .Modeling and simulation of potential robots facilitate design ,construction ,and inspection of real robots .Simulation is important for evaluation and prediction of robot behavior ,also to verify and optimize process path planning .Time and money will be saved ,and the optimization is necessary consideration in automating manufacturing Simulation create options to creative solving of problems .Inexistent objects can be visualized into existence ,investigated designed and tested .The methodology of this work is developing through Virtual Reality modeling language (VRLM) a 4 axis Scara robot system for handling small .things (see figure .1).The implement through VR depends upon high accuracy modeling of trajectory ,the structure to be built depends on the principles of solid-body modeling with VR technology[12].

Simulation on Matlab /Simulink software will reinforce .the results obtained by SD program the result of both will be presented ,and discussed .This work developed with D-H .Formulation; the kinematic equations of the SCARA robot, with robot dynamics and the actuators DC-servo motors for each joint.

Fig.1: 3D VR windows for the SCARA robot at position zero



II ROBOT KINEMATICS

The Table 1 defines the denavit-hartenberg (D-H) parameters specifying the SCARA robot

Table1. D-H parameters of robot

N°	**α_i**	**a_i**	**θ_i**	**d_i**	**σ_i**
1	0	a_1	θ_1	d_1	0
2	π	a_2	θ_2	0	0
3	0	0	θ_3	0	0
4	0	0	0	d_4	1

By using (D-H) convention [14], the transformation matrices result in.

$$ {}^{0}\mathbf{T}_1 = A_1 = \begin{bmatrix} c_1 & -s_1 & 0 & 0 \\ s_1 & c_1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{1}\mathbf{T}_2 = A_2 = \begin{bmatrix} c_2 & -s_2 & 0 & a_1 c_2 \\ s_2 & c_2 & 0 & a_1 s_2 \\ 0 & 0 & 1 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{2}\mathbf{T}_3 = A_3 = \begin{bmatrix} c_3 & -s_3 & 0 & a_2 c_3 \\ s_3 & c_3 & 0 & a_2 s_3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{3}\mathbf{T}_4 = A_4 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & d_4 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

$$ {}^{0}\mathbf{T}_4 = \begin{bmatrix} c_{123} & -s_{123} & 0 & a_1 c_1 + a_2 c_{12} \\ s_{123} & c_{123} & 0 & a_1 s_1 + a_2 s_{12} \\ 0 & 0 & -1 & d_1 - d_4 \\ 0 & 0 & 0 & 0 \end{bmatrix} $$

III INVERSE KINEMATICS OF THE SCARA ROBOT

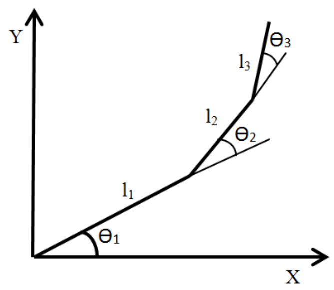


Fig.2: Inverse kinematics of the SCARA robot

The final equation representing the robot is[16]:

$$x = a_1 \cos(\theta_1) + a_2 \cos(\theta_1 + \theta_2) + a_3 \cos(\theta_1 + \theta_2 + \theta_3) \quad (4)$$

$$y = a_1 \sin(\theta_1) + a_2 \sin(\theta_1 + \theta_2) + a_3 \sin(\theta_1 + \theta_2 + \theta_3) \quad (5)$$

$$\Phi = \theta_1 + \theta_2 + \theta_3 \quad (6)$$

Z= -d4 (7)

And the inverse kinematics equations are:

$$\theta_2 = a \tan 2(\sin\theta_2, \cos\theta_2) \quad (8)$$

$$\theta_1 = a \tan 2(k_1 y_n - k_2 x_n)(k_1 x_n - k_2 y_n) \quad (9)$$

$$\theta_3 = \Phi - (\theta_1 + \theta_2) \quad (10)$$

$$d_4 = d_1 - d_3 \quad (11)$$

Where:

$$k_1 = a_1 + a_2 \cos\theta_2 \quad (12)$$

$$k_2 = a_2 \quad (13)$$

$$\sin\theta_2 \cos\theta_2 = \frac{x^2 + y^2 + a_1^2 + a_2^2}{2 a_1 a_2} \quad (14)$$

$$\sin\theta_2 = \sqrt{\pm(1 - \cos^2\theta_2)} \quad (15)$$

$$x_n = x - a_3 \cos\Phi \quad (16)$$

And:

$$y_n = y - a_3 \sin\Phi \quad (17)$$

Trajectory as the hadling robot, the workspace data are loaded on to the firing pulse to be Applied to the actuator of each motor joint, through the calculated command value post simulation, the robot's performance is evaluated through its movements, recordable in video or photograph, and observable according to scope [17]

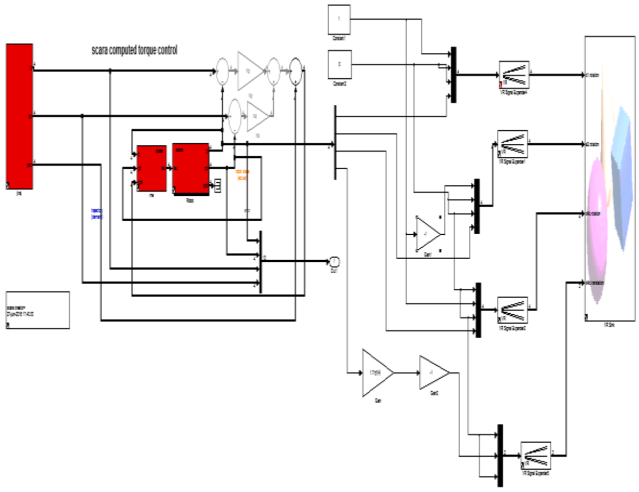


Fig.3: Block diagram simulation for SCARA robot with virtual reality model through trajectory of handling robot

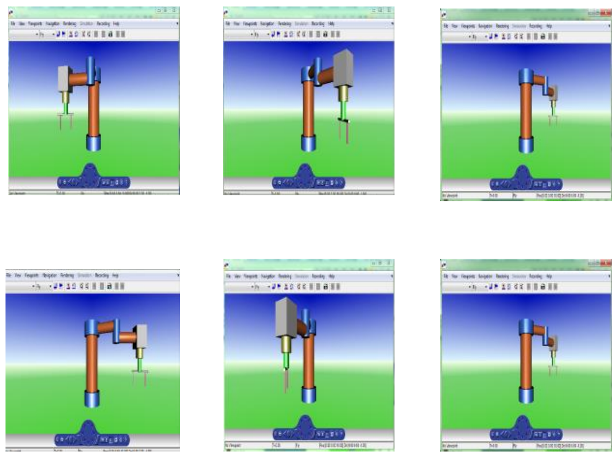


Fig.4: Implement of desired trajectory for SCARA robot

 ISSN 2769-2477

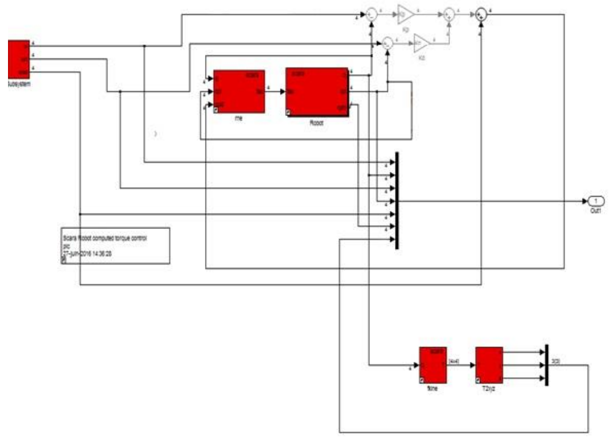


Fig. 5: Simulink Circuit for Calculated Torque Control

IV CONSTANT SET POINT CASES: CRITICAL DAMPING

The chronograms of the system in the two articular and Cartesian spaces, for the following simulation parameters: Kp=100 ; Kd=20 ; q0=[0 0 0 0] ; qf=[1.0472 0.7854 1.5708 20.00], tf = 1 second . Value is set from the response time data.

These corrector values correspond to a critical damping = 1

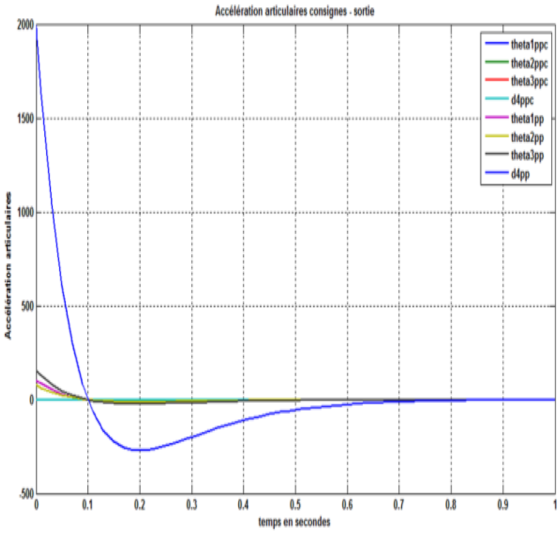


Fig.6

: Articular position

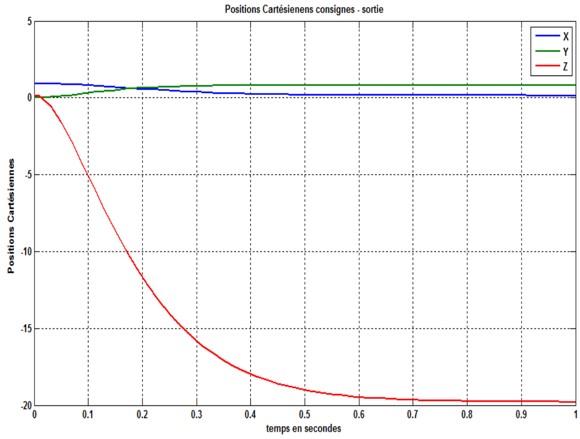


Fig7: Articular velocity

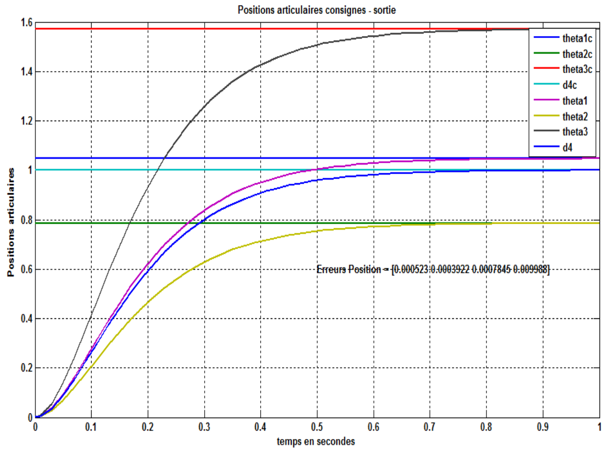


Fig8: Articular acceleration

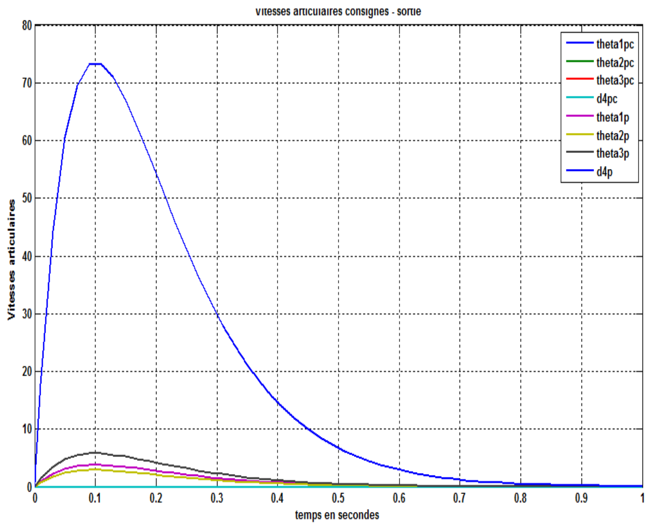


Fig.9: Cartesian position

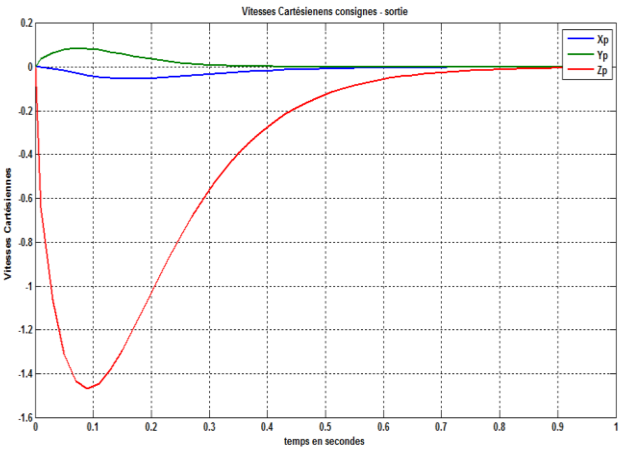


Fig.10: Cartesian velocity

V CONCLUSION

The results verify a complete mathematical modeling of the SCARA robot, including its direct and inverse kinematics equations, with the problem of inverse kinematics and the programming loop problem. The modeling is very precise for the search of the parameters of the robot. The model designed with the robot's matlab / simulink program has been developed, with the analytical solution IKP can be implemented manipulator robot depends on the precise analytical solution of IKP and the accuracy of the physical quantity of representation in the model mathematical. The implementation of a trajectory in a VR environment has many advantages with an industrial robot, Virtual Reality (VR) allows an appreciation of the behavior of robots through their graphical representation in a three-dimensional world. Augmented Virtuality (VA) provides additional tools for evaluating parameters during a given task.

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