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A simulation study for position control of VSAnkleExo in MATLAB/SimMechanics environment

MATLAB/Simmechanics ortamında VSAnkleExo'nun konum kontrolü için bir simülasyon çalışması

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Abstract

According to human biomechanics study, ankle joint musculoskeletal structure constantly changes joint stiffness during walking. Being inspired by human biomechanics, an ankle exoskeleton robot with an adjustable stiffness, named VSAnkleExo was designed and by using Simulation Environment MATLAB/SimMechanics, its position tracking simulation tests were carried out in this study. VSAnkleExo is intended to be used for the purposes of walking aid and rehabilitation. An effective position control of the robot is required for these purposes. Therefore, in this study, before testing the recommended controllers on the real robot, the position control simulations were applied on MATLAB/SimMechanics model of the robot. It is not easy to obtain the mathematical model of the robot because VSAnkleExo has a complex structure. For this reason, the control methods that do not need the mathematical model of the robot are tested here. In this study, firstly, a robot model was created by using MATLAB/SimMechanics. Then, trajectory tracking experiments and response experiments with disturbance were carry out on the model in order to reveal the efficiency of proposed fuzzy logic controllers. Besides, these experiments were performed with conventional PID and the all experiment results were compared. Experimental results show that proposed fuzzy PD+PID controller can influentially decrease reference tracking errors and acquire appropriate control performance. Furthermore, the controller is robust against external forces.

Keywords: Fuzzy PD+PID, ZTS fuzzy PD, Adaptive fuzzy controller, Variable stiffness actuators, Wearable ankle robot.

Öz

İnsan biyomekanik çalışmalarına göre, ayak bileği eklemi kas-iskelet yapısı yürüme sırasında eklem sertliğini anlık olarak değiştirmektedir. İnsanın vücudunun bu biyomekaniğinden esinlenilerek, VS-AnkleExo isimli ayarlanabilir sertliğe sahip bir dış iskelet robot tasarlanmış ve bu çalışmada MATLAB/SimMechanics simülasyon ortamı kullanılarak robotun pozisyon takip simülasyon testleri gerçekleştirilmiştir. VS-AnkleExo yürüme yardımı ve rehabilitasyon amaçları için kullanılması düşünülmektedir. Robotun bu amaçları yerine getirebilmesi için etkili bir pozisyon kontrolü gerekmektedir. Bu nedenle, gerçek robot üzerinde önerilen kontrolcüleri test etmeden önce, robotun MATLAB/SimMechanics modeli üzerinde pozisyon kontrol simülasyonları bu çalışmada sunulmuştur. VS-AnkleExo kompleks bir yapıya sahiptir. Bu yüzden robotun matematiksel modeline ihtiyaç duymayan kontrol yöntemleri burada test edilmiştir. Çalışmada ilk olarak MATLAB/SimMechanics kullanılarak robot modeli kurulmuştur. Daha sonra, önerilen bulanık kontrolcülerin etkinliğini ortaya koymak için yörünge takip ve bozuculu cevap deneyleri gerçekleştirilmiştir. Ayrıca deneyler geleneksel PID kontrolcü ile de gerçekleştirilmiş ve deney sonuçları karşılaştırılmıştır. Deney sonuçları, önerilen bulanık PD+PID kontrolcünün etkili bir şekilde pozisyon takip hatasını azaltabildiğini ve uygun kontrol performansı sunduğunu göstermiştir. Ayrıca önerilen kontrolcü bozuculara karşı sağlamdır.

Anahtar kelimeler: Bulanık PD+PID, ZTS bulanık PD, Adaptif bulanık kontrolcü, Sertliği değiştirilebilir eyleyici, Giyilebilir ayak bileği robot.

1 Introduction

Exoskeleton robots are special wearable devices that are involved in interaction with human limbs. These devices are used for different purposes such as improvement of the performance of healthy people [1] and rehabilitation of paralyzed people [2]-[4]. These devices use electric motors to achieve the required torque for exoskeleton joints. However, when safe physical interaction with human is requested, using stiff actuators in these devices is not ideal [5].

Human body can autonomously demonstrate a stable mobility in occasions with imponderable disturbances. Joint stiffness control is important for the adaptation of human to different tasks [6]. By adjusting the natural dynamics of a mechanical design, the system can both reduce energy usage and power requirement and provide a natural movement closest to the requested movement. In recent years, the compliant actuators having elastic components have been produced and implemented to joints of the exoskeleton. Series elastic actuators (SEAs) that are the first design of these actuators have been used to drive robots and subsequently implemented into the exoskeletons [7]-[9]. Apart from the SEA, the compliant actuators allowing stiffness change during movement, that is variable stiffness actuators (VSAs), are implemented into the exoskeletons as actuation unit. The actuator, which is called ARES, has been used as a knee joint to meet requirements of the ATLAS which is an exoskeleton robot used for children [10]. Zhu et al. (2017) implemented another VSA based on the same principle to assist movements of the knee joint for a robot designed to carry loads during motion [11]. The exoskeletons using these actuators include: MACCEPA [12], VSM [13] and

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KIT-EXO-1 [14]. As seen from studies in the literature, the compliant actuators are incorporated into the different joints of exoskeletons.

To get appropriate control performance while controlling the compliant actuators, different control techniques have been introduced. The most preferred approach is the use of control methods called as "classical", if the system (plant) to be controlled has single input and single output. Most researchers used PID controller in controlling of the compliant actuator [15]-[16] and in the different applications [17]. Zhang et al. (2016) proposes an active position control method by using PD controller on SEAs driving knee and hip joints of the exoskeleton [18]. Apart from "classical" control methods, robust control systems seem to be a suitable solution in the case of disturbing inputs that adversely affect system behavior. Madani et al. (2016) presented sliding mode controller for controlling of an orthosis preferred for rehabilitation [19]. A control structure, which involves a sliding mode adaptive controller and passivity based controller, was proposed to carry out the planned rehabilitation task of the exoskeleton in a safe manner [20]. Sometimes, different control strategies are preferred when the mathematical relation between input and output cannot exactly be established. Because of nonlinearity, friction and parametric uncertainty of serial VSAs, Guo et al. (2017) proposed a neural network-based adaptive controller depending on feedback linearization to deal with system uncertainties [21]. To control a mechanical leg, an adaptive fuzzy controller was used, at which a fuzzy logic control and PID control are combined [22].

Simulation and modeling are important in order to develop a mechanical system and to carry out control studies on it. Because it is difficult to predict how the control method to be applied on the designed system will respond. However, with the advanced simulation tools, the responses of the control methods to be applied on the real system can be predicted and the control parameters can be adjusted accordingly. In literature, there are different strategies applied by using simulation tools. Rezage and Tokhi used fuzzy PID controller on a device designed for the rehabilitation of elderly people in Visual Nastran 4D virtual environment [23]. Niu et al. (2013) applied fuzzy PID controller for controlling of the lower extremity exoskeleton robot by using ADAMS and Matlab/Simulink co-simulation [24]. Matlab/SimMechanics was used to control lower-body mechanism which is derived by four-bar for the purpose of rehabilitation [25].

In our previous article [26], the position control performance and sensitivity to external disturbances of hybrid controllers created by combining different types of fuzzy logic theory and classical PID control method implemented on VS-AnkleExo were evaluated experimentally. In this study, modelling, simulation and controlling of a compliant actuator with adjustable stiffness for a lower limb wearable ankle robot (VSAnkleExo) is presented in MATLAB/SimMechanics environment. VSAnkleExo [27] is intended for the purposes of rehabilitation and walking aid. Thus, the effective position control of VSAnkleExo is required. It is not easy to obtain the dynamic model of the robot because the robot has a complex structure and frictions between the mechanical elements. For this reason, performing different control strategies in a virtual environment is an appropriate method to study without detailed calculation. Therefore, it is preferred to use adaptive fuzzy controllers for controlling of the robot in virtual environment.

In this context, firstly, the model of VSAnkleExo was constituted by using MATLAB/SimMechanics [28]. Then, trajectory tracking experiments were carried out on the MATLAB/SimMechanics model of the robot in order to ascertain the efficiency of different controllers such as traditional PID, Fuzzy PD, Fuzzy PD+I, Fuzzy PD+PID and ZTS Fuzzy PD. Besides, the step and sinus response simulation experiments with external disturbance were performed to analyze the robustness of the control system. All results were given comparatively.

2 The kinematics and mechanical design of VSAnkleExo

What is expected of exoskeleton robot designs is that they can imitate human limb joints. Thus, it is of great importance to understand the functioning of human body joints while designing an exoskeleton robot. In order to understand the biomechanical functioning of lower limb joints during walking, scientific article produced by Shamaei et al. (2013) was analyzed [29]. According to this study, the ankle joint stiffness has been arranged to different statuses for different sub-phases of a walking period by the ankle neuro-muscular system. In order to simulate this stiffness of the ankle joint, the joint stiffness of the robot to be designed should be adjusted accordingly.

In here, being inspired by the human ankle biomechanics, a compliant actuator design with adjustable stiffness has been introduced. The schematic drawing of the designed actuator is given in Figure 1. The stiffness adjustment principle of this actuator depends on the adjustable lever arm mechanism. In the actuation unit of VSAnkleExo, the position of the force application point is changed while the position of the pivot and the point to which the spring is attached remains fixed. The actuator stiffness is changed by adjusting the position of the load application point on the lever arm. A second motor is used to adjust the position of the load application point.

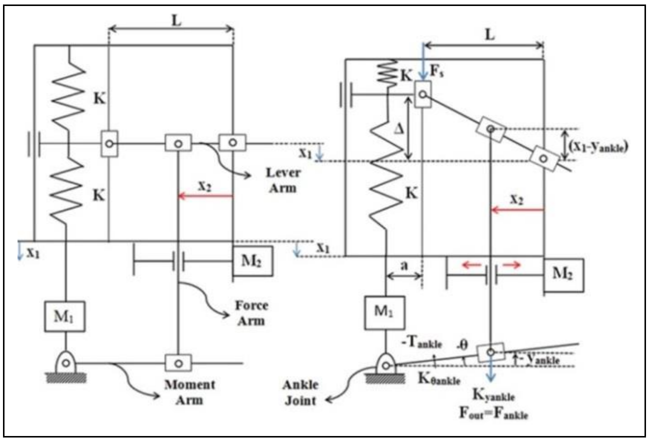


Figure 1. The schematic drawing of actuation unit of VSAnkleExo.

Figure 2 indicates the mechanic design of VS-AnkleExo robot.

The robot consists of four parts;

i. VSA,

ii. Embedded force sensors,

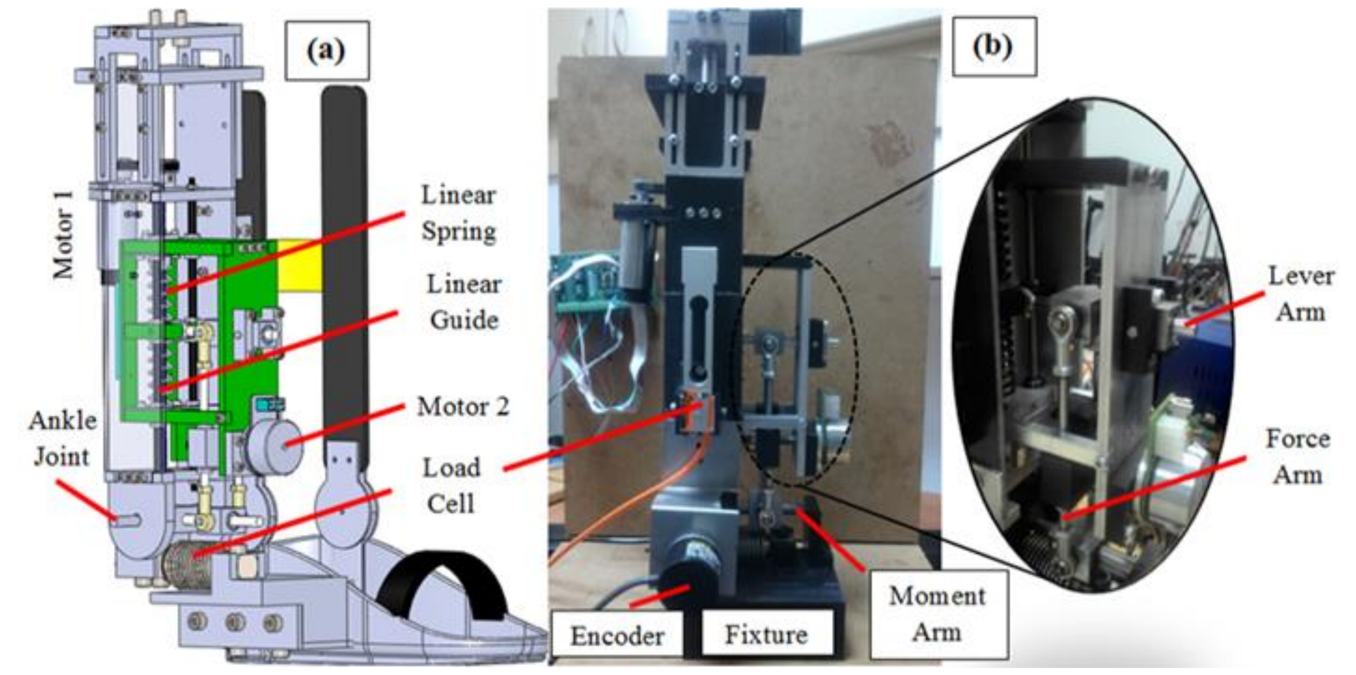


Figure 2(a): CAD design of VS-AnkleExo while output link is unloaded and (b): Actuator is at the middle stiffness.

iii. The mechanism for adjusting the robot according to the human lower limb height and iv) an ankle foot orthosis. The first motor (M_1) which provides torque for the ankle joint continuously drives the mechanism shown in green. Thus, the joint position is controlled through force arm on the lever arm and the moment arm. To change the stiffness of the ankle joint, a linearly moving mechanism driven by the second motor (M_2) is formed. In the mechanism of obtaining variable stiffness, M_2 is directly linked to ball screw to adjust the motion of the force arm. Therefore, the actuator stiffness can be changed by controlling the position of M_2.

In wearable robotic devices, it is important to measure the interaction forces to ensure security between user and device. Therefore, two force sensors are used in VSAnkleExo. The first sensor measures the forces generated during the contact of the device with the ground. The second sensor is used to measure the interaction torques/forces between VSAnkleExo and the user wearing it.

3 Controller structure

VSAnkleExo is thought to be used for purposes such as rehabilitation and walking assistance. Therefore, here the position control of VSAnkleExo is performed. The aim of the performed control studies is to demonstrate the position follow-up efficiency of robot by using different position controllers in MATLAB/SimMechanics. To carry out position control efficiency of VSAnkleExo, the algorithm shown in Figure 3 is used. In the control algorithm, q_{ref} is trajectory reference, q_m is the output angle of VSA, K is the adjusted stiffness of the actuator and G_{pos} is the position controller. Here, simulation experiments were performed by taking different controllers instead of G_{pos}.

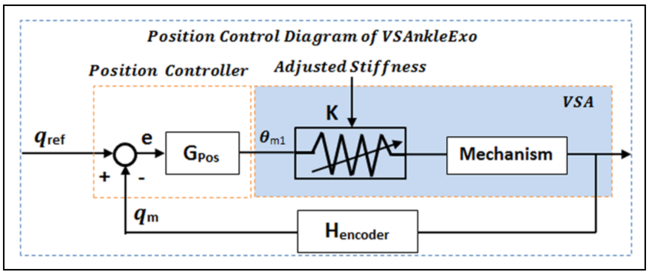


Figure 3. Position control block diagram of VS-AnkleExo.

Proportional–integral–derivative (PID) controller which is a conventional controller is used to control the robotic systems. But, the controller is sensitive to the system parameters and besides its parameters cannot be adjusted instantaneously during the control process. Thus, a solution is required to overcome non-linearity of the system and its complexity. Recently, the different algorithms such as fuzzy logic, which don't require a precise mathematical model, have been widely used [30]. In this context, apart from conventional PID, adaptive fuzzy controllers were developed by using fuzzy theory with PID. The basic of the controllers used in this study depends on the fuzzy control logic suggested by Khosla et al. (2013) for nonlinear systems [31]. In this study, position control efficiency of VS-AnkleExo for different stiffness value is investigated by using adaptive fuzzy controllers (Fuzzy PD, Fuzzy PD+I, Fuzzy PD+PID, ZTS Fuzzy PD) in MATLAB/SimMechanics. The fuzzy controllers in here regulate the parameters of the controller according to real time status, in order to achieve the desired performance. Figure 4 shows used the block diagram for fuzzy controllers.

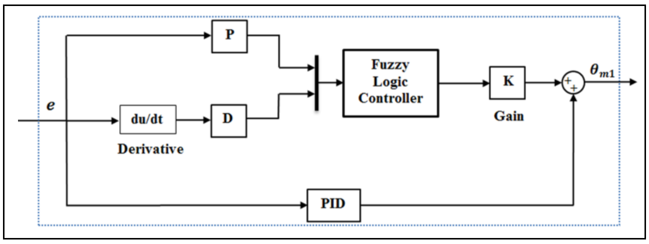


Figure 4. The block diagram of fuzzy PD+PID.

In the fuzzy logic controller, there are two different inputs and one output where the error and the deviation of the error are inputs of the controller and the output is signal of manipulation. The structure of the fuzzy logic comprises of three states;

i. Fuzzification step,

ii. An implication mechanism decided by fuzzy-based rules initially determined according to the state of the system,

iii. A defuzzification step. In fuzzy controllers, triangular membership functions (T) for both input and output elements were preferred except for ZTS Fuzzy PD. Seven triangular membership functions were defined (Positive Big (PB), Positive Medium (PM), Positive Small (PS), Zero Error (ZE), Negative Small (NS), Negative Medium (NM) and Negative Big (NB)) as given in Figure 5. After fuzzification, according to 49 rules defined in Table 1, the membership functions were used to achieve the output.

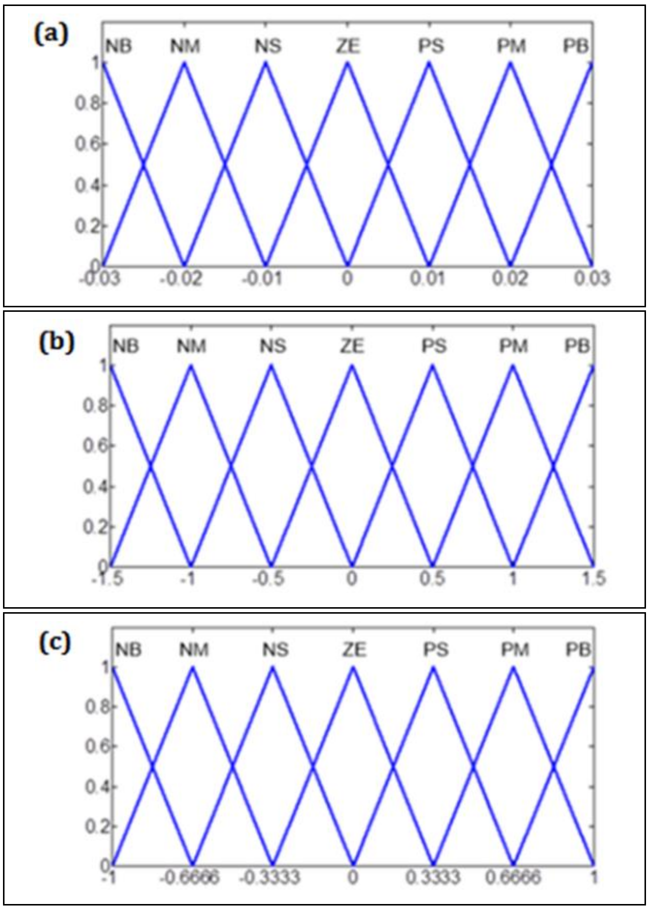


Figure 5. Defined membership functions for variables of (a-b): The input and (c): The output.

Table 1. Fuzzy inference rules for P and D parameters.

$e/\dot{e}$	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NB	NM	ZE
NM	NB	NB	NB	NB	NM	ZE	PB
NS	NB	NB	NB	NM	ZE	PM	PB
ZE	NB	NB	NM	ZE	PM	PB	PB
PS	NB	NM	ZE	PM	PB	PB	PB
PM	NM	ZE	PM	PB	PB	PB	PB
PB	ZE	PM	PM	PB	PB	PB	PB

It is important to note that in ZTS Fuzzy PD algorithm, Z and S type of the membership functions were used to keep the controller permanently active in endpoints of the limit values. Figure 6 shows Z and S type membership functions.

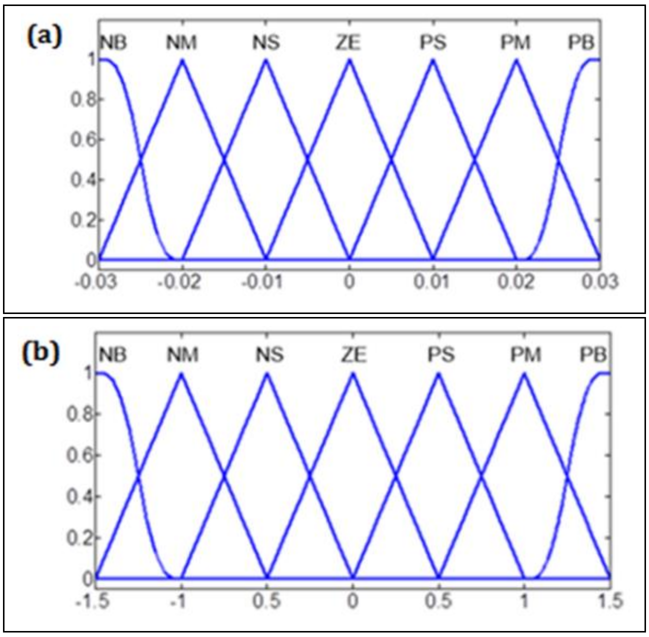


Figure 6. Membership functions in ZTS Fuzzy for (a): The error and (b): The deviation of the error.

4 Simmechanics simulation and comparison of experimental results

Model of VSAnkleExo is needed to carry out simulation experiments in virtual environment. Therefore, physical model of the real robot was obtained in MATLAB/SimMechanics environment [28] that is a simulation interface that can visualize the physical responses of mechanical systems. To get a realistic model of the robot, robot dimensions, properties of used materials, spring coefficients, joints are considered exactly the same in this work. Figure 7 shows the mechanical model and the simulation view of the robot defined in SimMechanics first generation. The building of the block diagrams in the SimMechanics was first initiated by creating the foot limb that would come into contact with the ground. A rotary joint around z axis was attached to the foot limb, thus the ankle joint was formed. The calf limb was created by using two body blocks. A prismatic joint was placed between two body blocks. DC motors are preferred to drive VSAnkleExo in the real design. However, in SimMechanics model, this task will be carried out by a linear actuator in the prismatic joint. Then, a rectangular lattice structure was formed to perform the ankle movement. To transmit the motor movement to the lattice structure, the linear springs were added to the model.

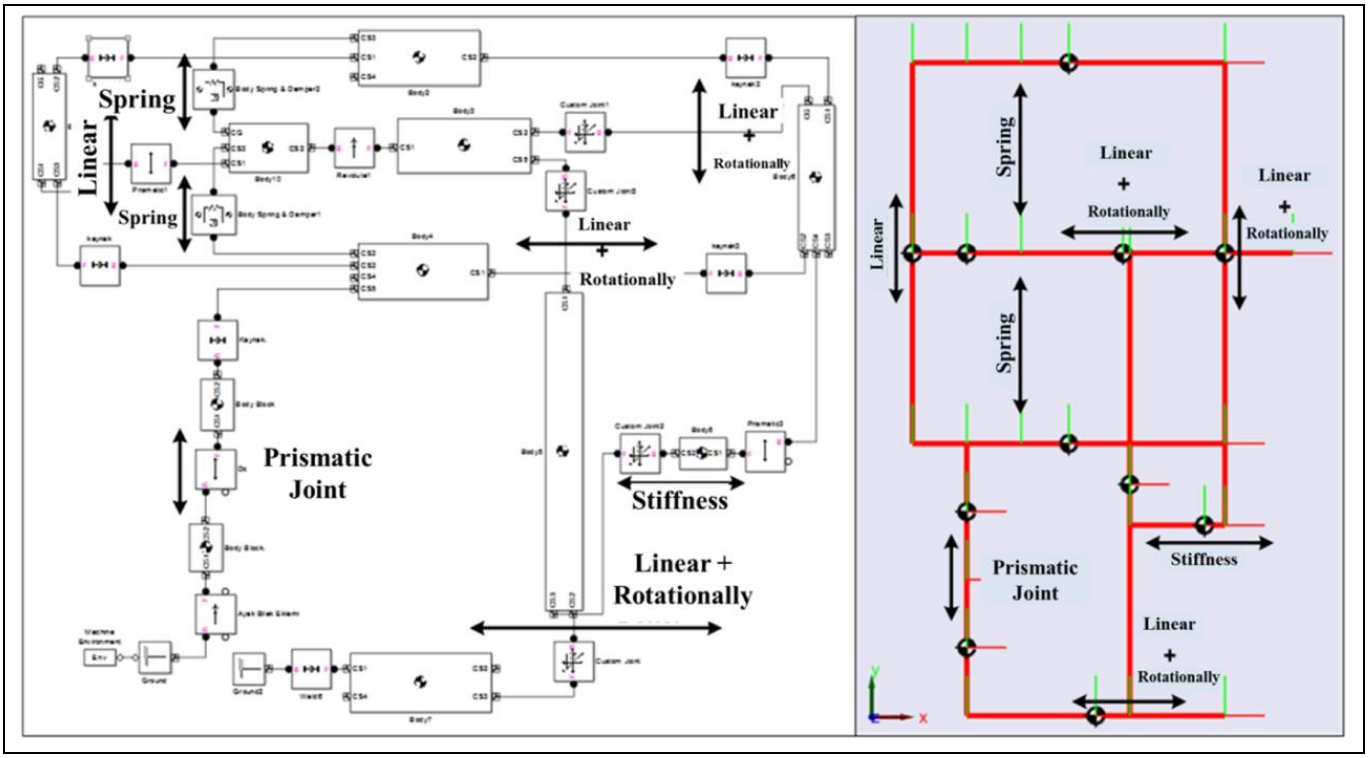


Figure 7(a): Complete SimMechanics block diagram of the robot and (b): Simulation of robot in SimMechanics.

As shown in the figure, they don't appear in the model, but can function. Finally, the other parts of the mechanism were attached to the model and the block diagram shown in Figure 7 was obtained. After block diagram of the robot was realized, control algorithm in Figure 4 was applied in MATLAB/SimMechanics

The PID controller was first applied for the position control of physical model that was created in the SimMechanics. In order to obtain the appropriate values of PID parameters, the second method proposed by Ziegler and Nichols was used. According to this method, it is firstly set $T_i = 0$ and $T_d = 0$. In this way, the PID controller is activated only with the P effect. K_p value is raised from 0 to a certain value that is K_{cr} at which point the system shows continuous oscillation. Therefore, gain K_{cr} and period of the continuous vibration P_{cr} are assigned experimentally. Then, PID parameters are found according to the formulas suggested by Ziegler and Nichols.

After the conventional PID controller, the adaptive fuzzy controllers (Fuzzy PD, Fuzzy PD+I, Fuzzy PD+PID, ZTS Fuzzy PD) mentioned in Chapter III were implemented into SimMechanics for the trajectory tracking experiments. For these controllers, the output signal was obtained by using the determined ranges of membership functions for the error and the deviation of the error. The ranges of membership functions were determined [-0.03, 0.03] for the error in [rad] and [-1.5, 1.5] for the deviation of the error in [rad/s]. The resulting output signal was multiplied by a stiffness coefficient K [Nm/rad] and then, it was given as the input of the linear actuator.

To test all controllers, step and sinus inputs were used as reference. Note that the simulation experiments were executed in different stiffness (K=1000 Nm/rad), medium (K=500 Nm/rad) and low (K=250 Nm/rad). Figures 8-9 show the step response and the sinus response of various controllers (conventional PID controller and adaptive fuzzy controllers) for three different stiffness coefficient values, respectively. Besides, the RMS error comparison of the controllers applied to the robot was presented in Table 2 and 3 for the step and the sinus inputs, respectively. As seen in Figure 8, the overshoot happens and the settling time of the system takes longer in PID controller. In Fuzzy PD and Fuzzy PD+I, no overshoot happens, but the settling time takes longer than PID controller. Compared to the other controllers, the response time of Fuzzy PD+PID and ZTS Fuzzy PD is shorter and there is no overshoot. However, when the RMS errors in Table 2 are examined, it is seen that Fuzzy PD+PID has shown slightly better results than ZTS Fuzzy PD for high and medium stiffness. For sinus input, when Figure 9 is examined, all controllers can be followed up properly for high stiffness. However, for medium and low stiffness, Fuzzy PD+PID and ZTS Fuzzy PD controllers have a higher performance in following the sinus reference. When Table 3 is examined in detail, Fuzzy PD+PID and ZTS Fuzzy PD have approximately the similar follow-up response. However, fuzzy PD+PID have less RMS errors.

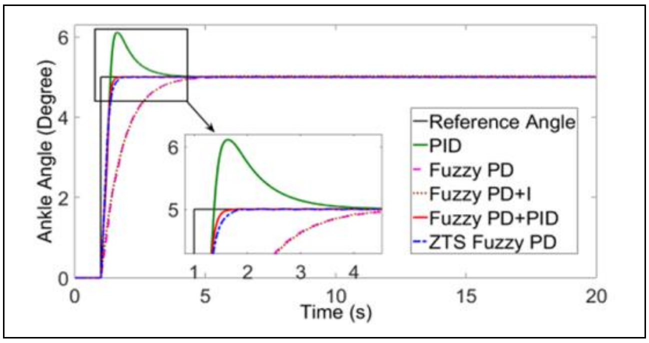
In here, the step and the sinus response simulation experiments with disturbance were performed to analyze the robustness of the system. These experiments were conducted on the simulation of the robot in SimMechanics. For this, the model of the robot was enforced by a disturbance force during the step input movement. The application point of disturbance force applied on the simulation is shown in Figure 10.

Table 2. RMS errors of controllers for the step input function.

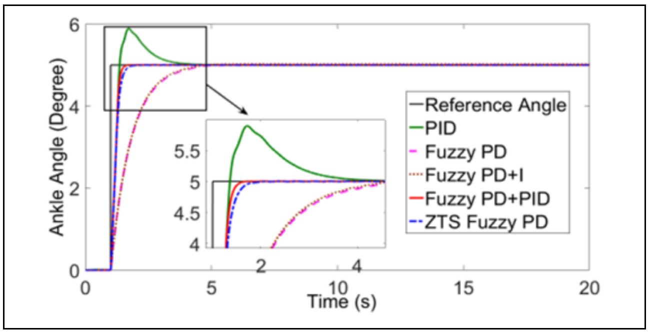
Controller	RMS Errors		
	High	Medium	Low
PID	0.41	0.42	0.45
Fuzzy PD	0.71	0.71	0.72
Fuzzy PD+I	0.70	0.70	0.72
Fuzzy PD+PID	0.38	0.39	0.41
ZTS Fuzzy PD	0.40	0.40	0.40

Table 3. RMS errors and max.-min. values of controllers for the sinus input function.

Controller	RMS Errors			Max.			Min.		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
PID	0.23	0.82	-1.03	0.57	1.16	-1.84	0.36	1.04	-1.41
Fuzzy PD	0.29	0.62	-0.48	0.36	0.82	-0.61	0.58	1.26	-0.92
Fuzzy PD+I	0.07	0.34	-0.27	1.11	0.47	-0.39	0.19	0.68	-0.71
Fuzzy PD+PID	0.002	0.025	0	0.001	0.025	-0.001	0.001	0.025	-0.001
ZTS Fuzzy PD	0.001	0.020	-0.025	0.0015	0.021	-0.03	0.002	0.023	-0.031



(a)



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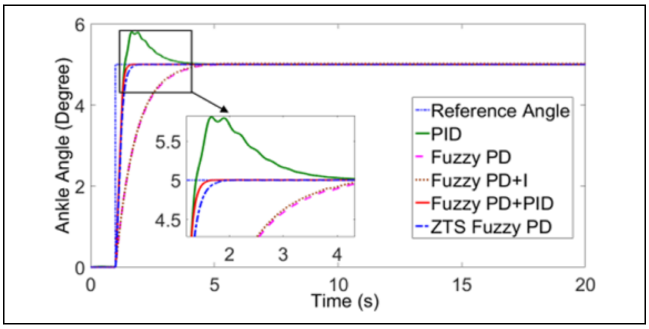
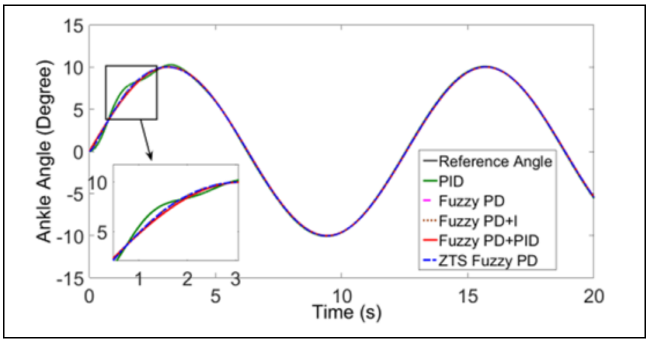


(c)

Figure 8. The step response of the different controllers for (a): High, (b): Medium and (c): Low stiffness values.



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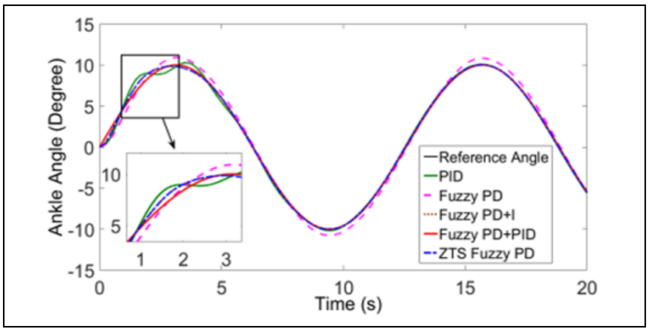

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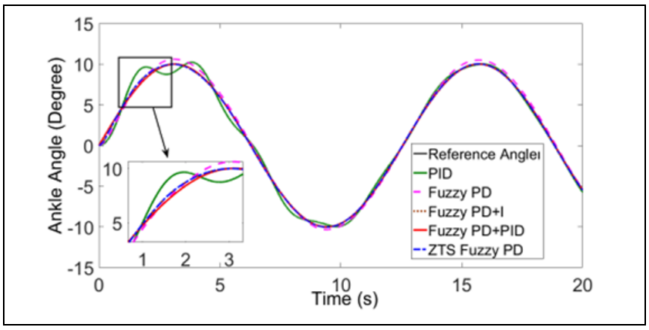

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Figure 9. The sinus response of the different controllers for (a): High, (b): Medium and (c): Low stiffness values.

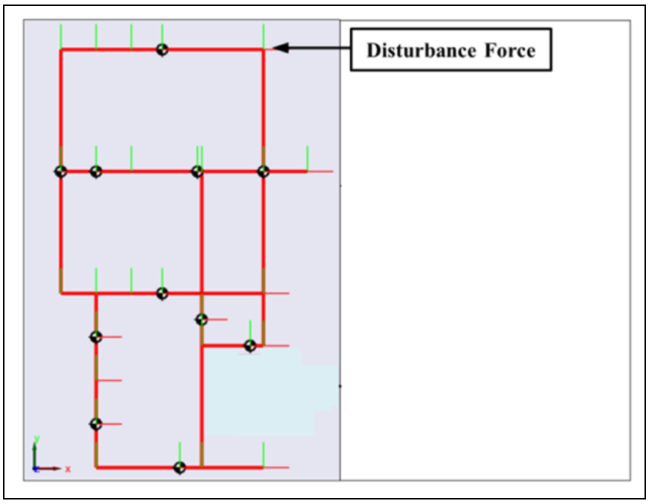


Figure 10. The application point of disturbance force applied on the simulation of the robot.

In the step experiments, the function of the step input was defined to move the robot about 5 degree in 1 s. Furthermore, to assess the robustness of different controller, the robot model was enforced by a disturbance force after the robotic system arrived at the steady state. The disturbance force in here was derived through signal builder command in SimMechanics. To measure the value of disturbance force, the force/torque sensor was located at the application point. The conducted experiment results are given in Figure 11.

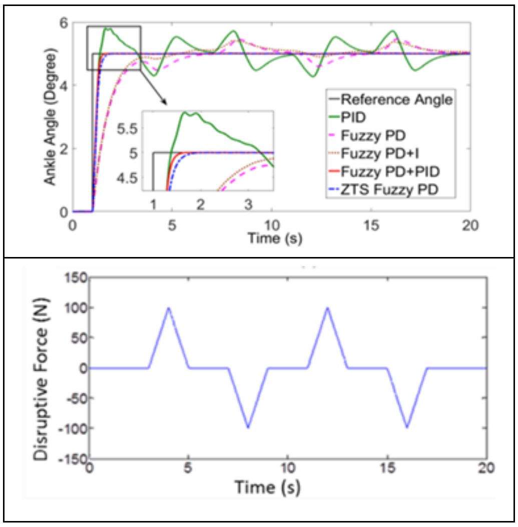
The RMS error comparisons of the controllers applied to the robot are presented in Table 4. As shown in Figure 11, Fuzzy PD+PID and ZTS Fuzzy PD are more robust against the undesirable perturbation. However, when the RMS errors in Table 4 are examined, it is seen that Fuzzy PD+PID has shown slightly better results than ZTS Fuzzy PD for high and medium stiffness.

Table 4. RMS errors of controllers for the step input function under disturbance forces.

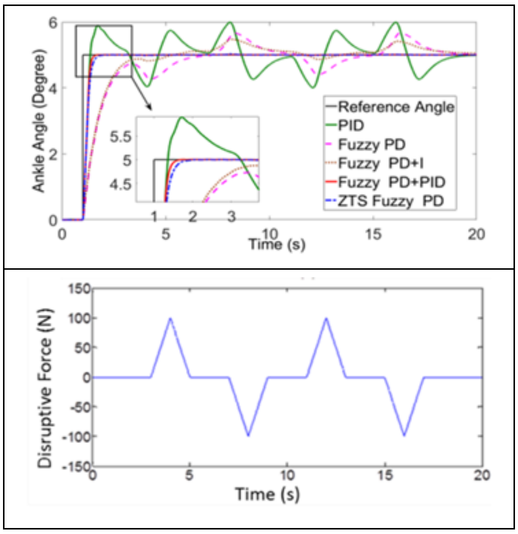
Controller	RMS Errors		
	High	Medium	Low
PID	0.52	0.62	0.84
Fuzzy PD	0.74	0.77	0.90
Fuzzy PD+I	0.71	0.71	0.72
Fuzzy PD+PID	0.38	0.39	0.405
ZTS Fuzzy PD	0.42	0.415	0.40

Similar to the step response simulation experiments, the sinus response simulation experiments with disturbance were performed to evaluate the robustness of each controller. For these experiments, the simulation experimental setup in Figure 10 was used. In these experiments, the robot was enforced by an external disturbance while tracking the robot reference. Figure 12 shows the conducted experimental results by using different controller. The RMS error comparisons of the controllers applied to the robot are given in Table 5.

When the results shown in Figure 12 are examined, it is seen that Fuzzy PD+PID and ZTS Fuzzy PD are more robust against the undesirable perturbation. Besides, Table 5 shows that Fuzzy PD+PID are usually better than ZTS Fuzzy PD.



(a)



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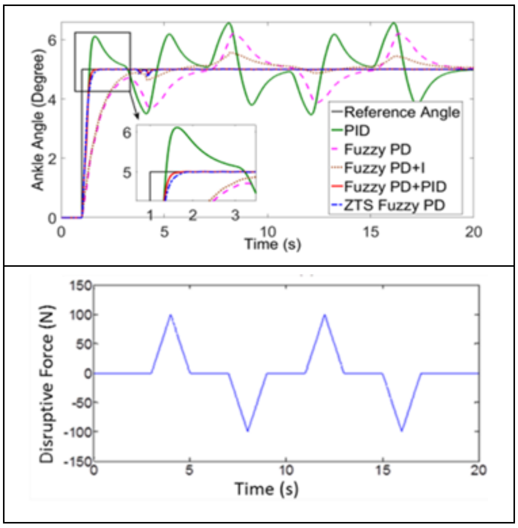
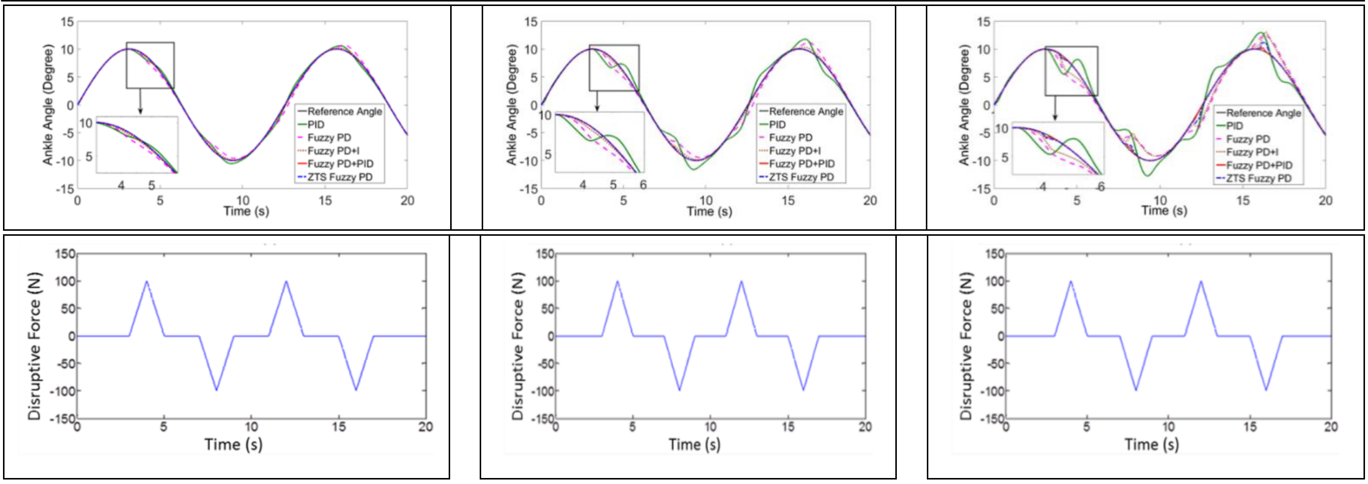


(c)

Figure 11. Results of the step experiments with disturbance; (a): High, (b): Medium and (c): Low stiffness values and applied external disturbance.

Table 5. RMS errors and max.-min. values of controllers for the sinus input function under disturbance forces.

Controller	RMS Errors			Max.			Min.		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
PID	0.33	0.74	-0.74	0.94	2.06	-2.07	1.52	3.21	-3.29
Fuzzy PD	0.49	1.15	-1.15	0.76	1.75	-1.70	1.37	3.01	-3.05
Fuzzy PD+I	0.15	0.35	-0.38	0.21	0.48	-0.52	1.14	2.66	-3.59
Fuzzy PD+PID	0.004	0.028	-0.012	0.022	0.03	-0.294	0.093	0.499	-0.568
ZTS Fuzzy PD	0.003	0.025	-0.008	0.005	0.025	-0.017	0.308	1.447	-1.752



(a) (b) (c)

Figure 12. Results of the sinus experiments with disturbance; (a): High, (b): Medium and (c): Low stiffness values and applied external disturbance.

5 Conclusions

In this study, various controllers, which does not need any mathematical model of the lower limb wearable ankle robot (VSAnkleExo), are compared in a simulation environment. Since this robot will be used for the purposes such as rehabilitation and walking aid, the position control of the robot is needed under safe regulations. However, before testing the recommended controllers in real-time environment situations, efficiency of all the controllers on the robot should be first considered in SimMechanics platform.

This paper deals with the modelling, simulation and controlling of VSAnkleExo in a detailed manner. In the study, firstly, a mechanical model of the robot was created by using MATLAB/SimMechanics. Then, the different simulation experiments were performed on the robot model in order to indicate the efficiency of proposed controllers PID, Fuzzy PD, Fuzzy PD + I, Fuzzy PD + PID and ZTS Fuzzy PD. In the first case, the model of the robot was expected to follow the step and the sinus references. In the second case, a disturbance force was applied to the robot model for analyzing the robustness of the proposed controllers during the step and the sinus movement. Simulation results demonstrate that Fuzzy PD+PID and ZTS Fuzzy PD maintain a better reference tracking and show better control performance when compared with the other controllers. Also, they are robust against applied disturbance forces. In this study, a traditional PID controller and a Fuzzy PD controller have been tested individually as well as being connected to each other in parallel and working simultaneously. It has been observed that the position errors are relatively high when the PID and Fuzzy PD controllers are used alone. However, when these controllers work in a parallel configuration, since one of the two controllers is constantly active in the error domain, they can better realize error compensation. The good performance of the ZTS Fuzzy PD controller can also be explained by the fact that the Z and S type of the membership functions were used to keep the controller permanently active in endpoints of the limit values. This study clearly shows that if a Fuzzy PD controller is to be used alone, membership functions with Z and S features should be chosen.

6 Author contribution statements

In the scope of this study, the Hasbi KIZILHAN the literature review, the design, examining the results and in the assessment of obtained results, Bahri ŞEKERCİ in the formation of the idea, supplying the materials used and the design, Ergin KILIÇ in the assessment of obtained results, the spelling and in the formation of the idea, Özgür BAŞER checking the article in terms of content and the design were contributed.

7 Ethics committee approval and conflict of interest statement

There is no need to obtain permission from the ethics committee for the article prepared.

There is no conflict of interest with any person / institution in the article prepared.

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