A PID-BASED CONTROLLER FOR A KNEE EXOSKELETON EMPLOYING A METAHEURISTIC ALGORITHM TO PREVENT STIFFNESS IN BEDRIDDEN PATIENTS

Dr Annisa Jamali and Siti Nur Hanisah Zuhari

CONTENT

INTRODUCTION

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Bed bounded patients

Prolonged bed rest can weaken the entire body including the lower limb

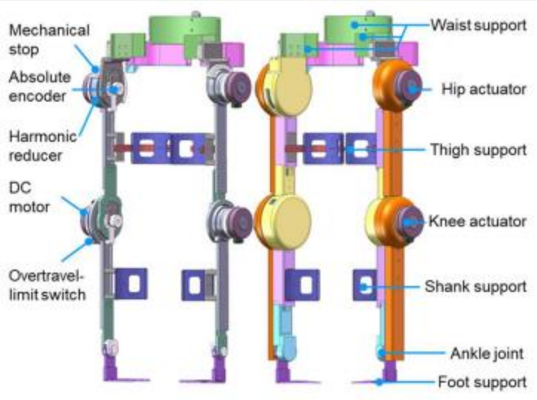
Muscle has shrunk cannot be stretched that lead to a limited range of motion

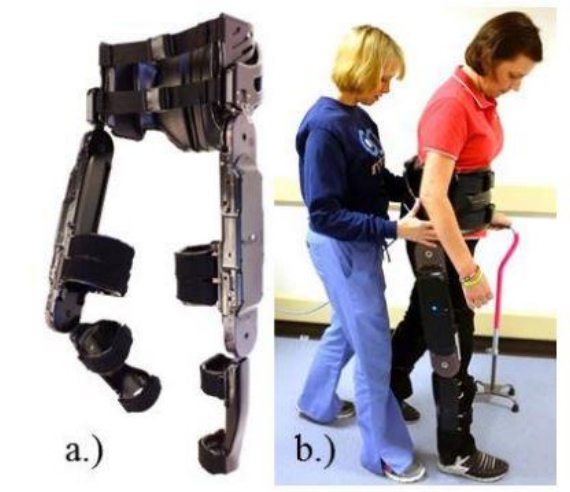
To Avoid: Exercises

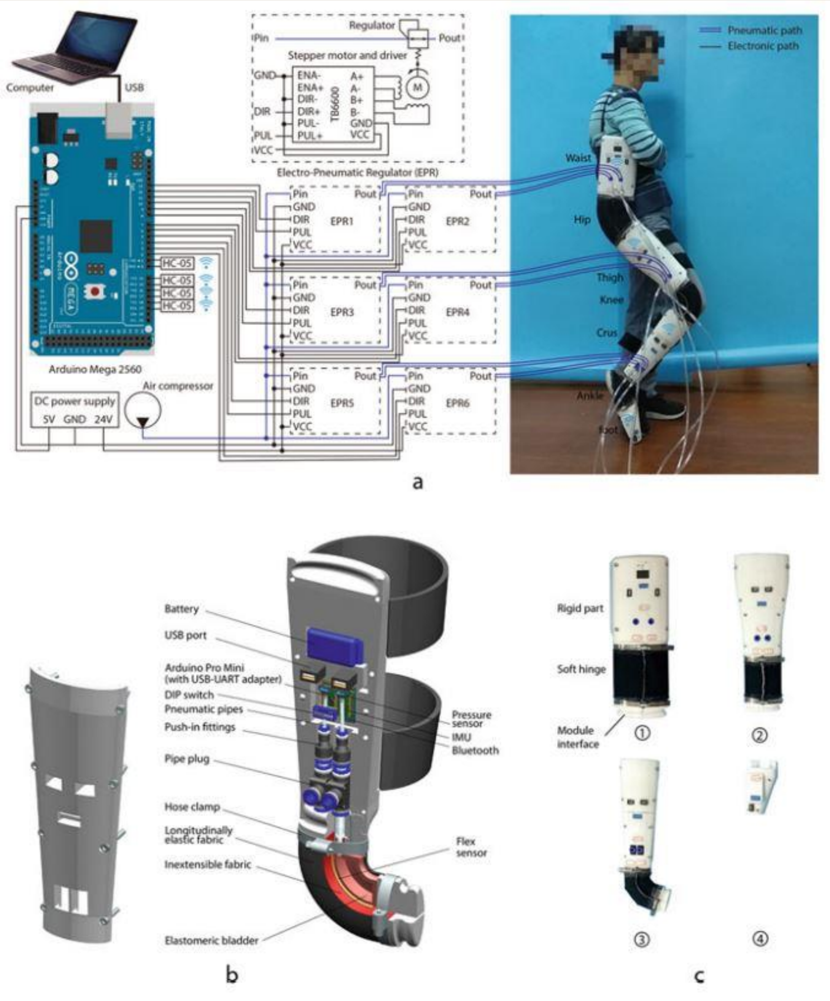
How and Who?

Rehabilitation Robot

INTRODUCTION

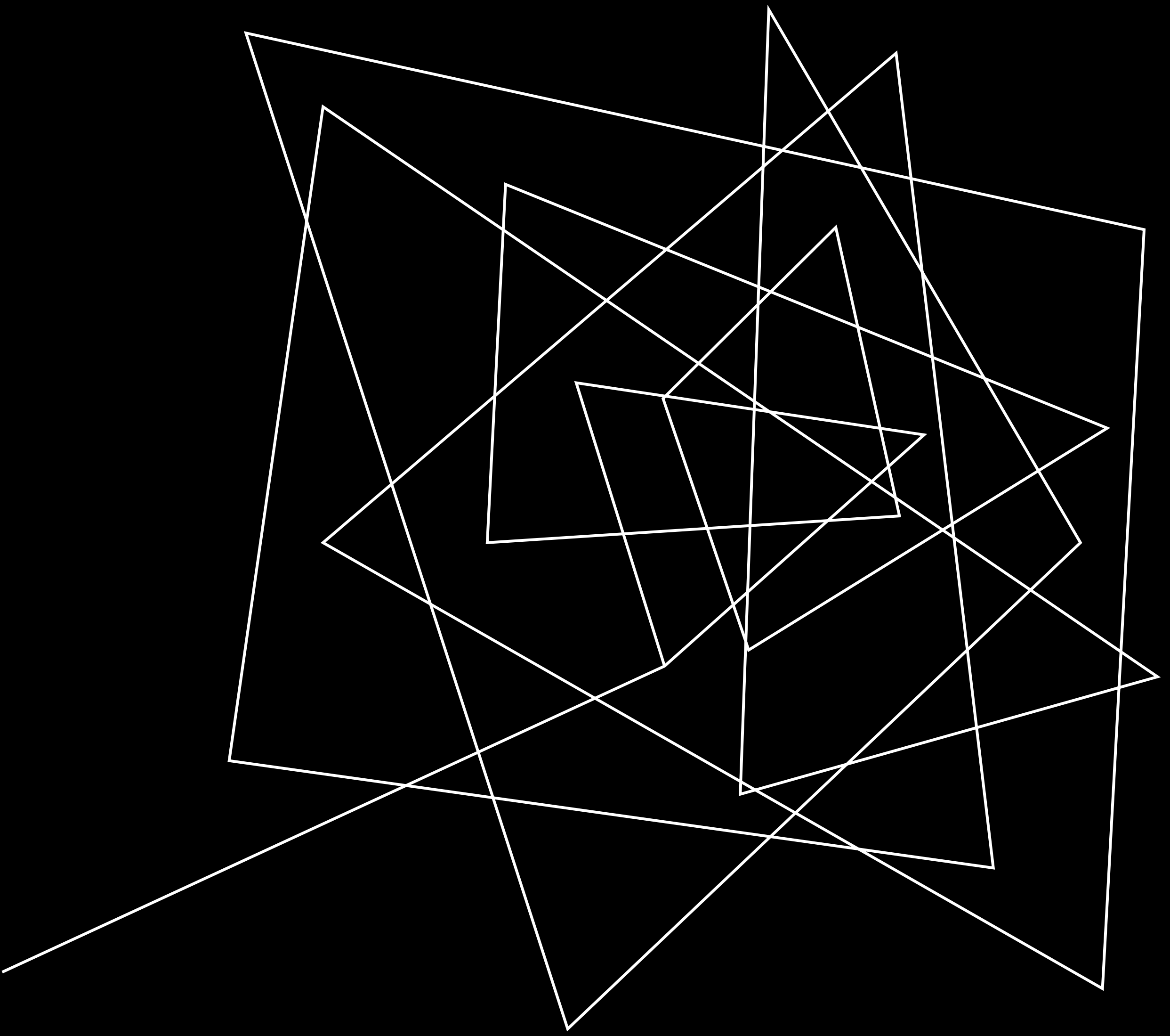






INTRODUCTION

Author	Characteristics							
	Portable	Home Setting	Training Activities	DOF	Training Modalities	Motor	Type of Controller	Position
Trung and Duc (2017)	No	No	Hip, knee, and ankle	6	Active	DC Motor	Adaptive Fuzzy Controller	Walking
Wei et al (2021)	-	-	Hip and Knee.	6	Active and Passive	Servo Motor	Iterative Learning Control (ILC) Algorithm	Walking
Richa et al (2021)	Yes	Yes	Hip and Knee	2 and 4	Active	-	FLC-PID-DFA	Walking
Majeed et al (2016)	-	-	Hip, Knee and Ankle	3	Active	-	Proportional-derivative Particle Swan Optimisation Active Force Control (PD-PSO-AFC)	Walking
Lei et al (2018)	Yes	Yes	Knee	1	Active	Hydraulic Damper	Hybrid Fuzzy-PID Controller	Walking
Herianto et al (2016)	Yes	Yes	Knee and Ankle	2	Passive	DC Motor	PID-LQR	Sitting
Hongfang et al (2017)	Yes	No	Hip and Knee	4	Active	Motor Putter	Sliding Mode Control (SMC)	Walking
Mingxing et al. (2019)	Yes	Yes	Knee	4	Active	DC motor	PD-PID Controller	Sitting
Sapiee et al (2019)	Yes	No	Hip, knee, and ankle	6	Active	Actuator	Simple PID Controller	Walking
Xusheng W. et al (2021)	No	Yes	Knee, and ankle	4	Active	DC motor	PID Controller	Multi-posture (Sitting, lying, and standing)
Jonas et al (2016)	Yes	Yes	Knee and Ankle	3	Active and Passive	DC Motor and ElMO Whistle Motor	PID Controller	Walking and Squatting
Bernhard et al (2021)	Yes	No	Hip, Knee and Ankle	6	Active	Parallel elastic actuator	PI Controller	Siting, Standing and Walking



SYSTEM MODELING

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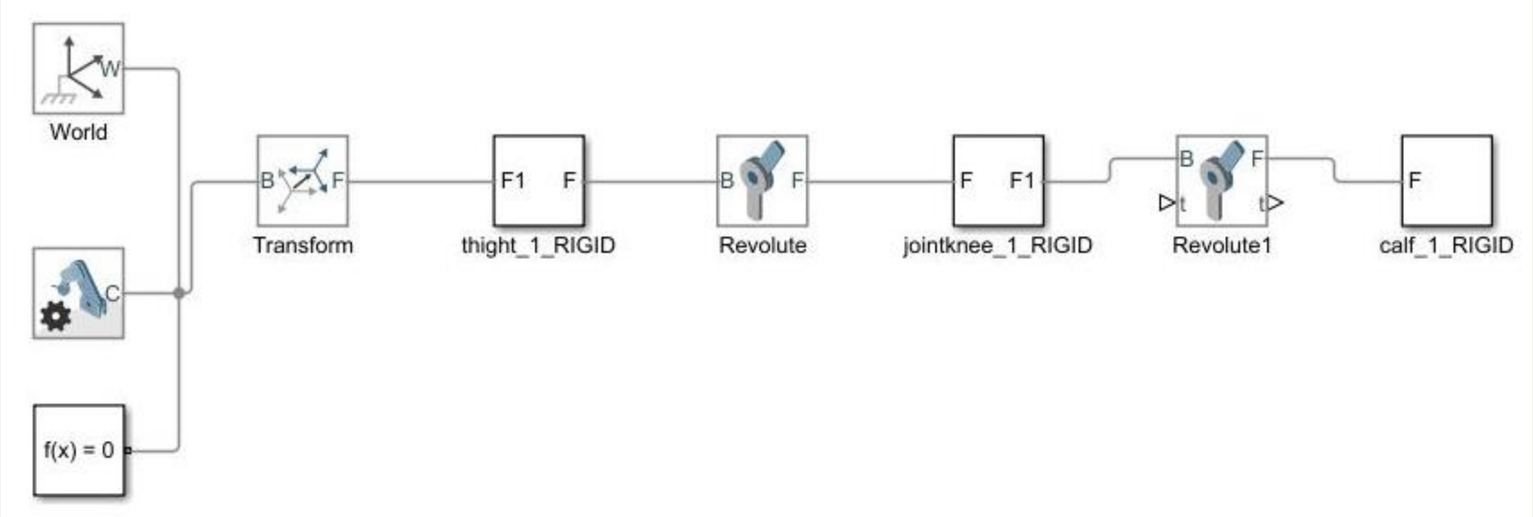


Figure 1. Physical Modeling of the Knee Exoskeleton

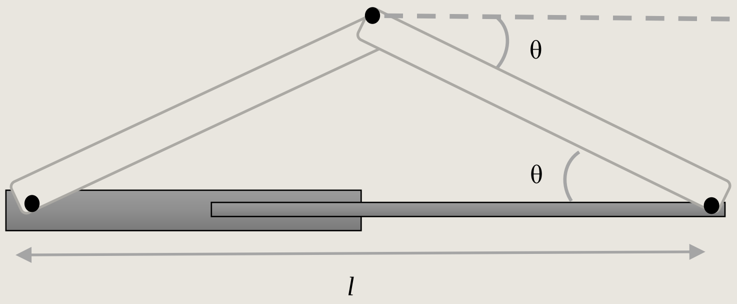
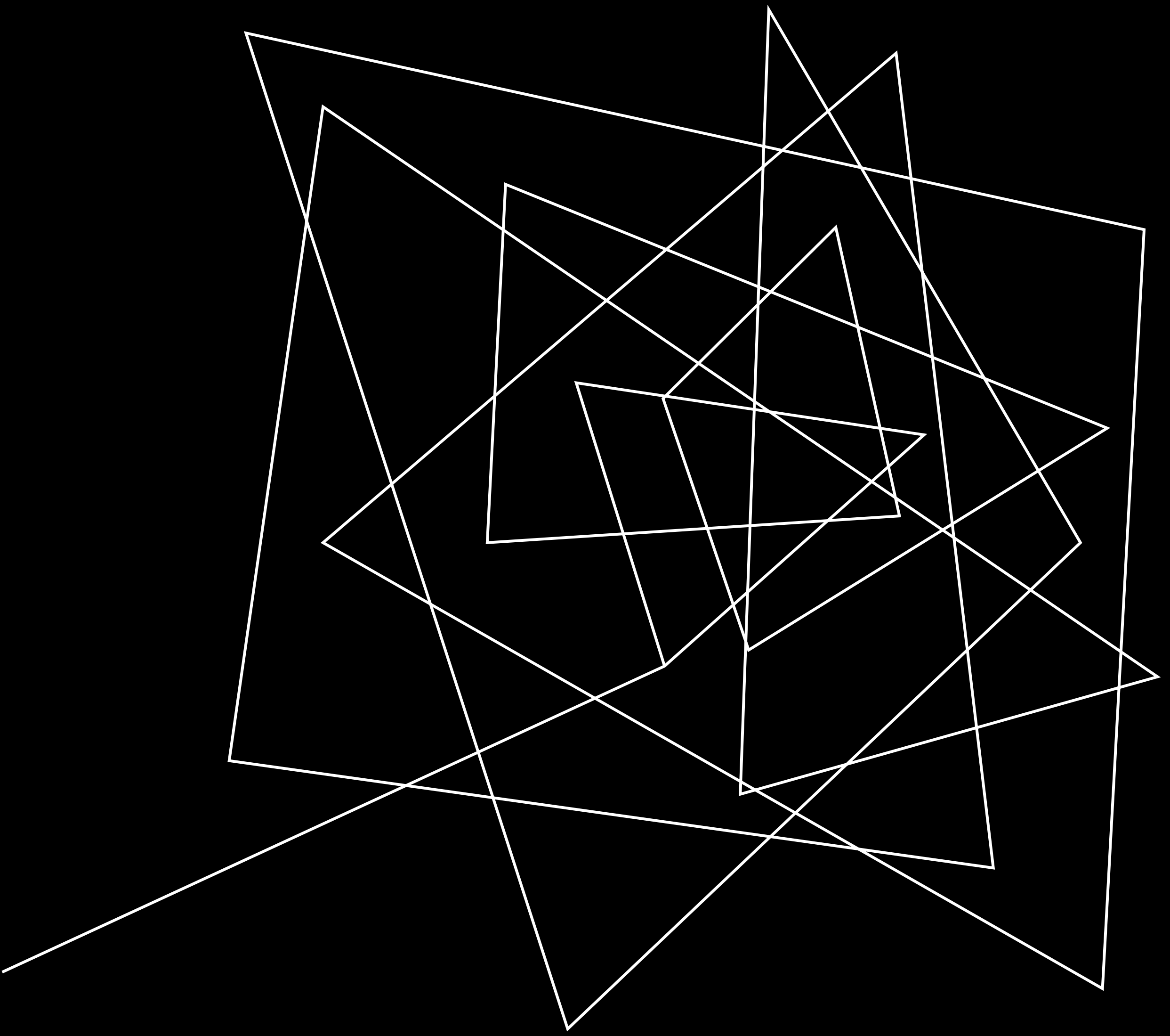


Figure 2. Simplified model of the Knee Exoskeleton Mechanism



CONTROLLER DESIGN

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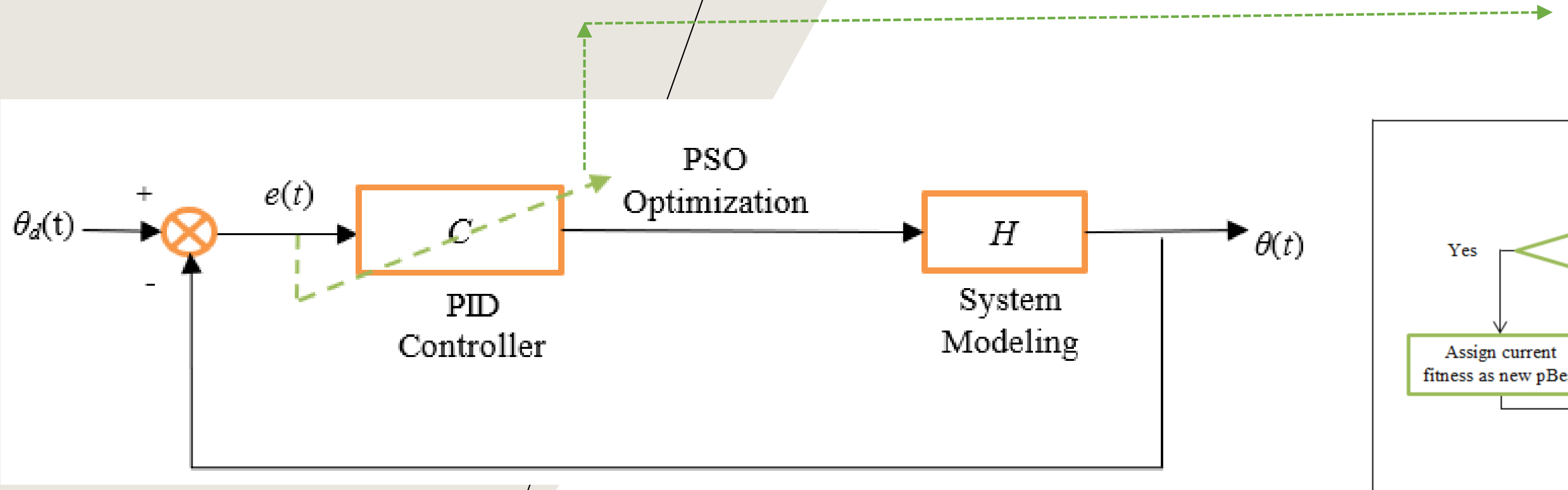

Figure 2. Block diagram of the system.

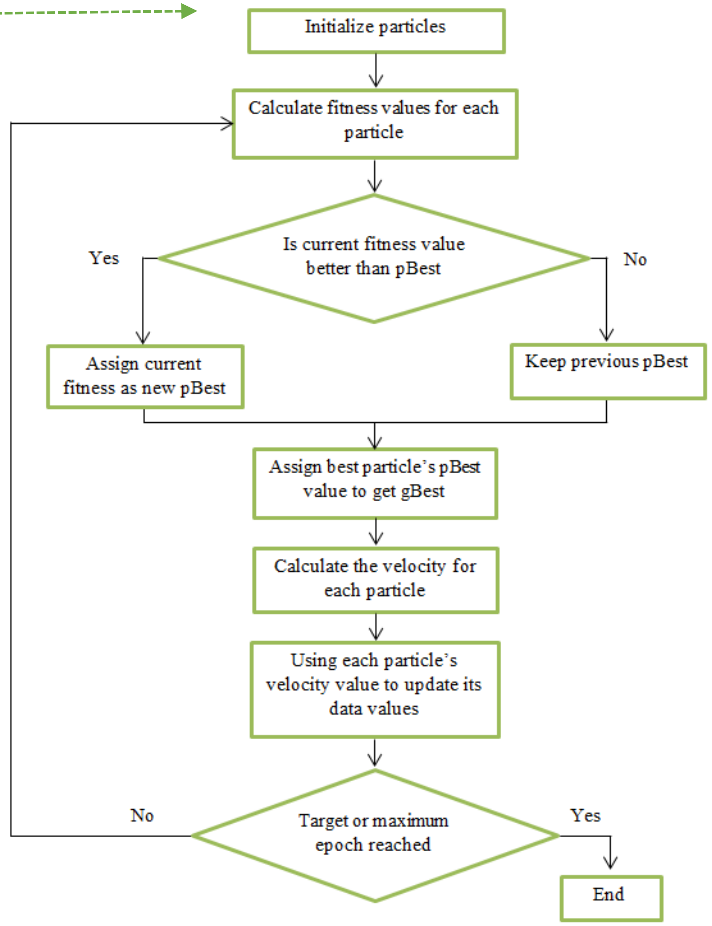

Figure 2. Flow chart of particle swarm optimization algorithm

CONTROLLER DESIGN

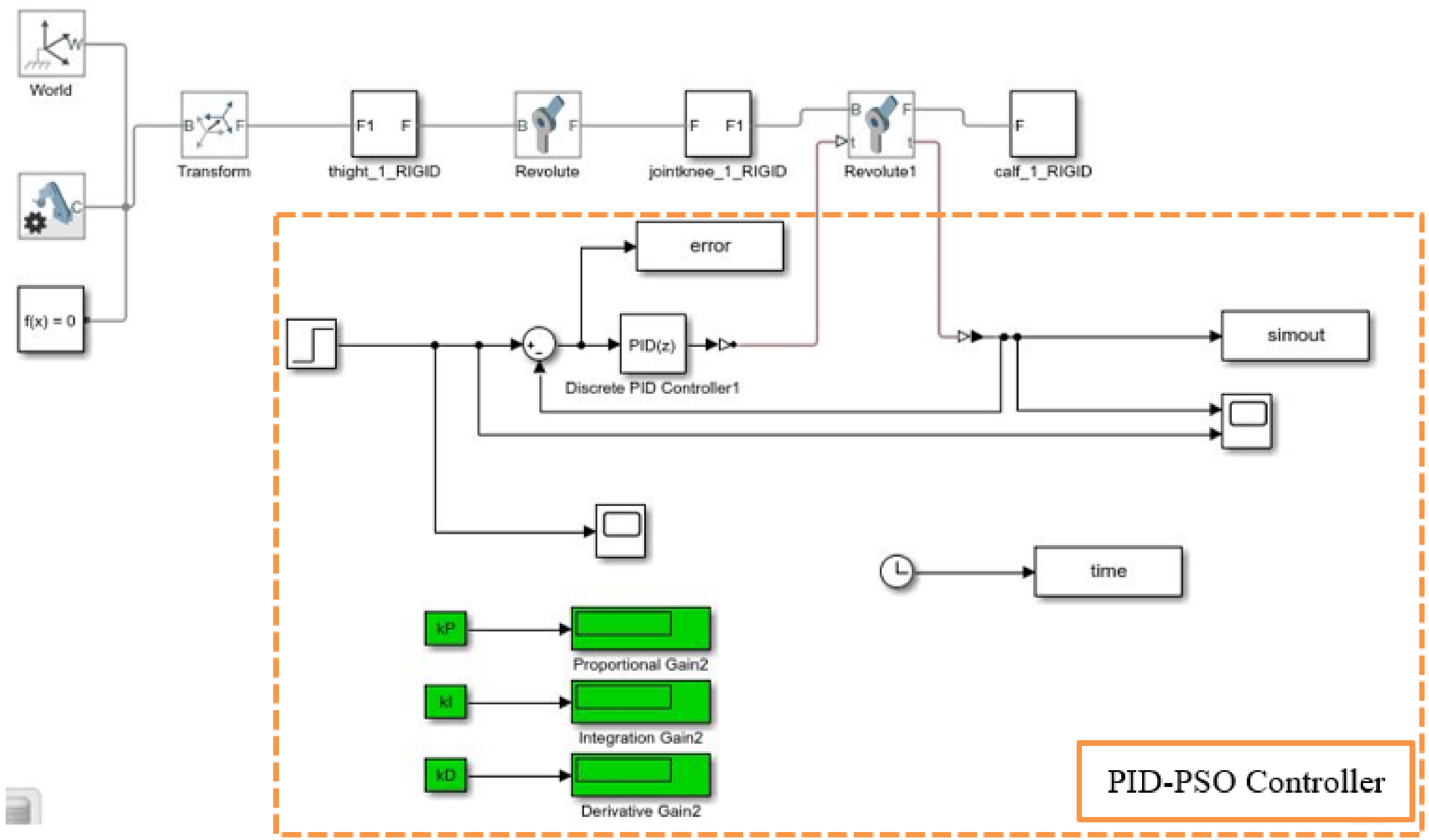

Figure 3. Simulink model for PID-PSO control system of knee exoskeleton

RESULTS AND DISCUSSION

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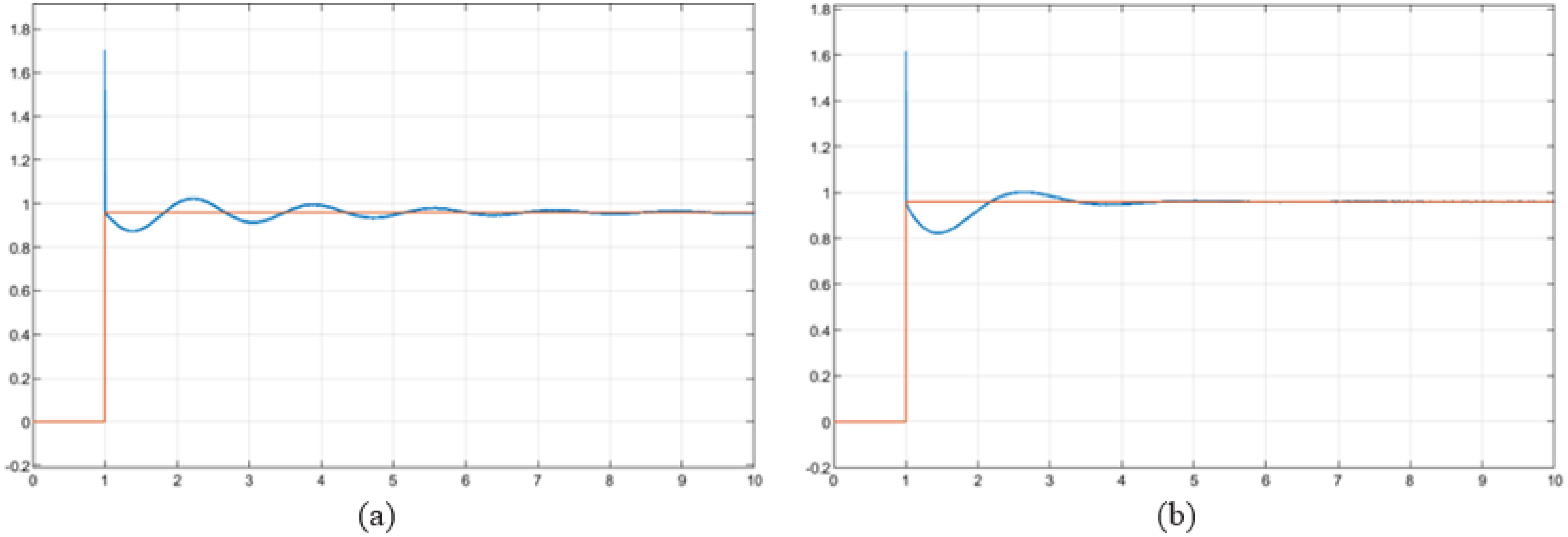

Figure 4. (a)Graph for PID controller, (b) Graph for PID-PSO controller

RESULTS AND DISCUSSION

Table 1. Comparison between the data of PID and PID-PSO

Method	Proportional (P)	Integral (I)	Derivative (D)	Rise Time	Settling Time	Overshoot	Steady-state Error
PID	0.486	36.78	2.56	7.28 e-05	5.79	78.21	0.0032
PID-PSO	3.574	30.24	0.4444	6.99e-05	3.09	68.10	0.0024

$$Percentage\ of\ Improvement = \frac{Old - New}{Old} \times 100\% \tag{5}$$

Table 2. Percentage of improvement of intelligent control system

	Rise Time	Settling Time	Overshoot	Steady-State Error
Improvement (%)	3.86	46.58	12.93	25

CONCLUSION

- An intelligent PID-PSO controller for knee exoskeletons has been developed.
- Acceptable steady-state error, settling time, and rise time for maintaining the desired reference angle.
- Demonstrated significant improvement over manually tuned PID controllers.
- PID-PSO controllers provide superior results to PID controllers.

THANK YOU

Dr Annisa Jamali

jannisa@unimas.my