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RETRACTED: The quadriceps muscle of knee joint modelling Using Hybrid Particle Swarm Optimization-Neural Network (PSO-NN)

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Retraction

Retraction: The quadriceps muscle of knee joint modelling Using Hybrid Particle Swarm Optimization-Neural Network (PSO-NN) (*J. Phys.: Conf. Ser.* **819 012029)**

Published 03 May 2023

This article has been retracted by IOP Publishing following an allegation that this article may contain tortured phrases [1].

IOP Publishing has investigated and agrees the article contains a number of nonsensical phrases that feature throughout the paper and lack of context surrounding the use of nanoparticles [2], to the extent that the article makes very little sense. This casts serious doubt over the legitimacy of the article.

IOP Publishing wishes to credit PubPeer commenters [3] for bringing the issue to our attention.

The authors neither agree nor disagree to this retraction.

[1] Cabanac G, Labbe C, Magazinov A, 2021, Tortured phrases: A dubious writing style emerging in science. Evidence of critical issues affecting established journals, arXiv:2107.06751v1

[2] Saadi Bin Ahmad Kamaruddin et al 2017 *J. Phys.: Conf. Ser.* **819** 012029

[3] <https://pubpeer.com/publications/22276FF313DD4E624B73B2CAD7EEB0>

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The quadriceps muscle of knee joint modelling Using Hybrid Particle Swarm Optimization-Neural Network (PSO-NN)

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Abstract

Neural framework has for quite a while been known for its ability to handle a complex nonlinear system without a logical model and can learn refined nonlinear associations gives. Theoretically, the most surely understood computation to set up the framework is the backpropagation (BP) count which relies on upon the minimization of the mean square error (MSE). However, this algorithm is not totally efficient in the presence of outliers which usually exist in dynamic data. This paper exhibits the modelling of quadriceps muscle model by utilizing counterfeit smart procedures named consolidated backpropagation neural network nonlinear autoregressive (BPNN-NAR) and backpropagation neural network nonlinear autoregressive moving average (BPNN-NARMA) models in view of utilitarian electrical incitement (FES). We adapted particle swarm optimization (PSO) approach to enhance the performance of backpropagation algorithm. In this research, a progression of tests utilizing FES was led. The information that is gotten is utilized to build up the quadriceps muscle model. 934 preparing information, 200 testing and 200 approval information set are utilized as a part of the improvement of muscle model. It was found that both BPNN-NAR and BPNN-NARMA performed well in modelling this type of data. As a conclusion, the neural network time series models performed reasonably efficient for non-linear modelling such as active properties of the quadriceps muscle with one input, namely output namely muscle force.

Keywords—artificial neural network, backpropagation, nonlinear autoregressive, quadriceps muscle

1. Introduction

The unpredictability of the electrically invigorated muscle due to the nonlinear and time changing nature of the framework with autonomous variables. Most muscle models constructed either on test or physiological based are not relevant for control applications [1].

The muscle is expected to comprise of two segments: a dynamic power generator and parallel inactive properties. Dynamic properties incorporate muscle initiation and muscle compression. Detached properties incorporate latent thick minute and flexible minute. Enactment elements give the actuation required by muscles to create power. Muscle enactment is processed from the beat width of electrical incitement. The withdrawal flow portrays the mechanical constriction and connection of muscle and

ligament including their length and speed. Muscle constriction results from blend existing apart from everything else point and minute speed relations.

Most muscle models constructed either on trial or physiological bases are not proper for control applications, since these models portray every muscle highlight alone, and at some point, there is no association between the demonstrated components which may forestall displaying the entire muscle as one model. This paper shows the advancement of dynamic properties of electrically animated quadriceps muscle utilizing nonlinear autoregressive neural system.

2. Related literatures

Diverse sorts of muscle model are utilized for various purposes. The extent stretches out from systematic models which depend on physical properties of the muscle, either at a minute or at plainly visible level, to observational models which are numerical depictions of the information yield qualities of the muscle [2]. A broad survey of different demonstrating methodologies can be found in [3]. Angles which are especially pertinent to displaying of misleadingly animated muscle are talked about in [4]. [5] look at model structures considering minuscule investigation, perceptible examination and simply scientific models.

The most generally utilized tiny model is the cross extension demonstrate, the essential standards of which were created by [6]. It expects to depict the muscle attributes at a minute level by displaying the procedures inside a solitary muscle fiber. This sort of model is on a fundamental level helpful to depict all qualities of muscle, as every single model parameter depend on physical parts, which makes it exceptionally well known amongst researcher. Be that as it may, the tiny methodology makes a depiction of the whole muscle exceptionally troublesome as parameters at the level of muscle filaments must be distinguished. It likewise drives rapidly to vast frameworks of nonlinear fractional differential conditions which are hard to handle. Parameters of a Huxley-sort model are hard to translate as far as the plainly visible muscle attributes. Various whimsical cross-span models have been proposed which make distinctive suspicions than those of Huxley, e.g. [7].

The regularly referred to plainly visible muscle model depends on the depiction by [8] with a lot of exploratory information and results. The Hill-based muscle models are prominent as their parameters depict commonplace ideas identified with the sarcomere structure and they comprise of progressive conditions considering exploratory results. This makes them more ideal than those that rely on upon speculations as it is asserted that they are more precise [9]. In any case, for the recognizable proof of parameters of model parts uncommon tests are vital which may not be pertinent in all circumstances. [10] built up the least complex model with the most evident accomplishment of the structure being its 'assignment independency', which has been guaranteed to be accomplished through including nonlinear relations for four major model properties, for example, contractile component torque-speed, serial flexible segment, parallel component, contractile component dynamic muscle torque-edge. In any case, this would clearly build the model multifaceted nature.

The most referred to and exceptionally complete paper that locations Hill based demonstrating through investigating muscle-ligament cooperation is given by [11]. Slope based models ascertain the muscle power as the result of three free tentatively measured elements, specifically the power length property, the power speed property and the initiation progression of the neural information. The model has been streamlined by expecting that the muscle enactment and muscle withdrawal elements are uncoupled as appeared on Figure 1. Neural excitation acts through actuation progression (excitation-compression coupling) to produce an interior muscle tissue state (muscle initiation). Through muscle constriction flow this enactment empowers the cross-connects and builds up the muscle power. A broad survey of different minute demonstrating methodologies can be found in [2].

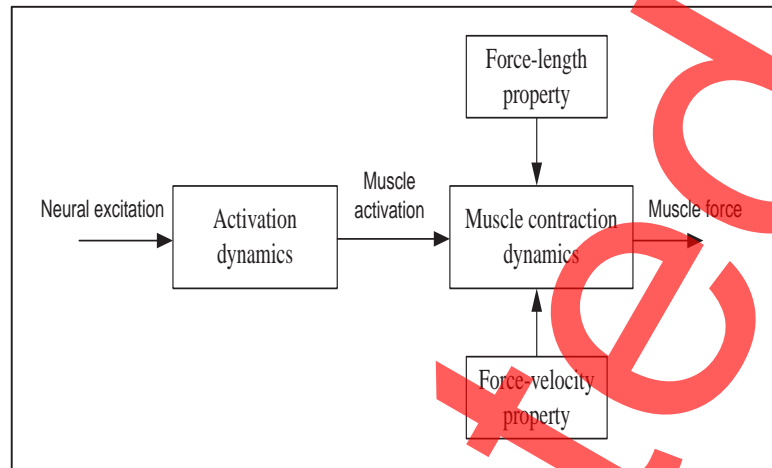


Figure 1. Hill based muscle model

Most models based on scientific bases are not reasonable for FES control applications [1]. One approach to build up this model for FES control application is to utilize scientific models. In this way, experimental model methodologies, which expect to portray the information yield attributes of muscle (frequently constrained to conditions regular in FES applications), and whose structure is reasonable for the outline of incitement controllers, get to be valuable. Subsequently, numerous analysts have created scientific models of electrically fortified muscle in light of Hill-sort [12], Huxley-sort [13], diagnostic methodologies [14] and physiology approach [15]. A survey of experimental displaying approaches for muscle is given in [4].

The utilization of numerical models can altogether improve the outline and assessment of shut circle control systems connected to FES [16]. Scientific models can be utilized to advance a comprehension of the framework and they can be utilized to foresee the conduct of the framework [3]. Exact models of manufactured muscle enactment in sound or paraplegic subjects have been produced yet the complexities of the framework coming about scientific representation have an expansive number of parameters that make the model recognizable proof procedure troublesome.

Muscle comprises of dynamic and latent properties. In this study, a partition is made between the dynamic and the aloof muscle properties. So far just the dynamic muscle properties have been considered. The aloof muscle attributes, for example, consistency and flexibility are allocated to the joint as considered in [14] and are incorporated into the following segment.

3. Background of data

The subject taking part in this work was a 50-year-old deficient hemiplegic stroke male with 10 years' post stroke with stature = 170 cm and weight = 80 kg. Educated assent was gotten from the subject. The study was affirmed by the Ethics Board of the University Malaya Medical Center, and we confirm that all material institutional and legislative controls concerning the moral utilization of human volunteers were taken after.

In this work, an exploratory setup together with the estimation instrumentation was created to reproduce the knee joint flexion movement with practical electrical incitement. As appeared in Figure 2, the trial setup includes five noteworthy parts – a PC controlled design, utilitarian electrical stimulator, power touchy resistor (Figure 3), adaptable sensor 4.5" and stroke tolerant.

In the PC controlled arrangement, the stimulator gadget can be simply associated with PC through USB interface port with an examining time of 0.05 s. Saturated self-glue anodes are used which make

utilization of a multilayer structure to supply an equalization in appropriating the incitement current over the terminal surface. The 50mm×90mm rectangular PALS neurostimulation terminal was utilized as a part of this study. These terminals were produced using sewed stainless steel filaments which frame the conductive surface.

HASOMED current controlled incitement gadget with 8 channel is utilized to send the sign to the muscles proposed by [10] [12]. The units are little, and the generator can convey trains of jolts with variable current qualities and variable heartbeat widths. The stimulator gadget is worked by a touch board with light as appeared in Figure 4.

The sensors signals obtained through the Arduino Mega System. The fundamental sign molding circuits, for example, hostile to associating channel have been incorporated with the Arduino Mega System. The gathered information is put away and examined utilizing Intel Core i5 Processor and Matlab/SIMULINK programming.

Keeping in mind the end goal to play out the distinguishing proof test, the subject sat on a seat with armrests, which permitted the lower leg to broaden unreservedly. The edge and constrain of the leg is recorded utilizing Matlab/SIMULINK programming through the Arduino Mega. Development of the lower leg and hip joint were not contemplated to decrease the quantity of level of flexibility and made exclusively subordinate upon the knee joint position. Hence amid the test the lower leg and hip joints of the subject were altered. The lower leg point was altered utilizing the Velcro strap to be at 0°. The hip point was set at around 100° from the flat utilizing straps. The strap was non-versatile, and the power delicate resistor was in this manner used to quantify isometric knee augmentation and isometric dorsiflexion minutes [4].

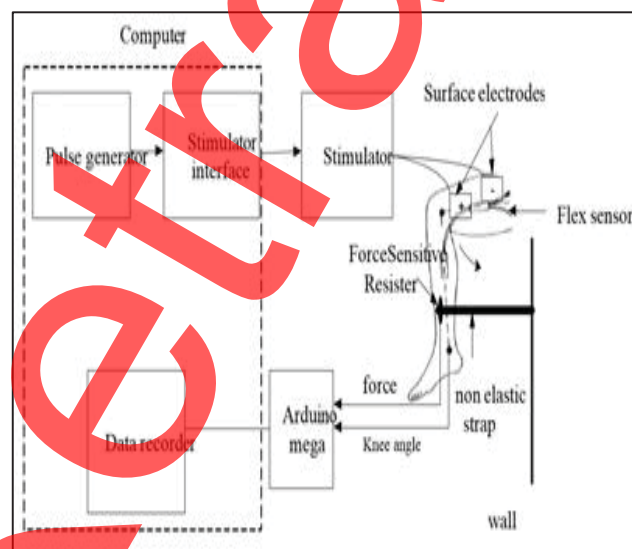


Figure 2. Computer controlled FES system



Figure 3. Functional electrical stimulation (HASOMED)



Figure 4. Force sensitive resistor

The essential goal of the examination is to build up the distinguishing proof electrical incitement leg test. Test outline is a significant stride for a fruitful ID strategy, which is more, the tests are not connected to a mechanical or physical procedure, but rather to a person, specifically, a stroke understanding. This implies the test plan must be given specific consideration.

Table 1. Technical characteristics of the simulator

Parameter	Range Specification
Current	0 . . . 126mA in 2mA steps
Pulse width	0, 20 . . . 500 μ s in 1 μ s steps
Pulse form	Singlet/Doublet/Triplets

The conveyance of electrical incitement can be altered to decrease weariness and advance power yield by modifying the related incitement parameters. A full comprehension of the settings that oversee the incitement is essential for the wellbeing of the patient and the achievement of examination. Thought ought to be given to the recurrence, beat width/term, obligation cycle, force, incline time, beat design, program span, program recurrence, and muscle bunch enacted [5].

With the end goal of proficient neural system preparing, exploratory information that contains adequate data in regards to the framework conduct over the whole working reach is important. In this work, the measure of heartbeat width created by FES and the power development are recorded for demonstrating purposes [6][7][8][9].

The left side quadriceps muscle gathering is animated with surface cathode: a PC controlled stimulator conveys adjusted bipolar incitement beats. The recurrence of the beats has been altered at 20 Hz and the electrical current was restricted to 40mA to maintain a strategic distance from muscle fit. For the distinguishing proof test, 4 trials were done as it was obvious that the fit rate was poor. Between each two tests there was a rest time of no less than 10 min with a specific end goal to take out weakness [4].

In the wake of gathering the crude information from the trial seat, preprocessing of the recorded yield is required for proficient machine learning. This errand includes the standardization of all information inside an altered extent interim of - 1 and +1. Standardization of all information inside an altered extent can guarantee that all the supreme estimations of the model inputs and yields utilized for the framework recognizable proof are of the same greatness request. Normalizing signals makes the count more sensible when assessing model parameters, especially when a little change in the excitation sign can bring about a vast change in the response [11].

There are 1334 information acquired from the trials, 934 information re utilized as preparing information set while 200 information are utilized for testing and acceptance information set. The system design for quadriceps muscle model comprises of one info and one yield. The parameter of information must have an impact on the coveted yield. For this model, power was chosen as model information. This information is utilized to affect in a NARMA muscle model (Figure 5).

4. Methodology

In this research, we adapted the nonlinear autoregressive (NAR) model. The NAR model is a forecasting model that utilizes past output values to predict future values of a time-series data. It can be expressed as

$$y_t = g^d [x(t-1), x(t-2), \dots, x(t-n_t)] + \varepsilon_t \quad (1)$$

where

y_t = current value of muscle force at time t ,

$x(t-1), x(t-2), \dots, x(t-n_t)$ = input lags,

$\varepsilon(t)$ = error at time t ,

g^d = backpropagation neural network to estimate the model.

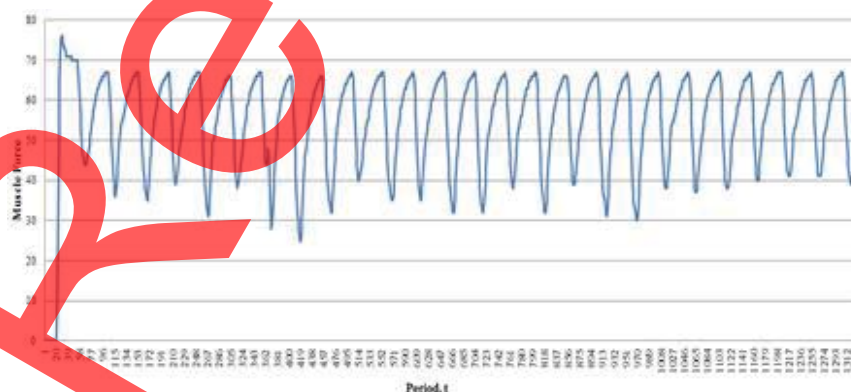


Figure 5. Data set for model parameter. The input a torque (Nm), and the period is in terms of seconds

Nonlinear Moving Average (NARMA) is the expansion from the NAR. Backpropagation is a nonlinear capacity approximator enthused by the organic neural system. A managed system, it can gain from an arrangement of inputs and yields to find the relationship between them.

This calculation is a various layer perceptron (MLP) approach which comprises of layers of essential processors called units. The units are masterminded into layers, each with their capacity. The info and yield layers acknowledges or discharges inputs and yields from or to the environment. The concealed layer is in charge of programmed taking in the relationship between them.

The interconnections between these units have weights which convey the signs between the units. The preparation procedure adjusts these weights interactively, often by the backpropagation calculation.

In this examination, we utilized digression sigmoidal activity capacity from info layer to shrouded layer. At that point, we utilized purelin-straight initiation capacity from shrouded layer to yield layer. The flowchart of the exploratory setup can be found in Figure 6. ANN model choice is normally finished with the fundamental cross-acceptance process. That is, the in-test information is part into a preparation set (70%), a validation (15%) set and a testing set (15%). Table II demonstrates the parameter change utilized as a part of this exploration.

The ANN parameter are assessed with the preparation test, while the execution of the model is assessed with the testing test, bolstered or affirmed by the outcomes from the approval set. The best model chose is the one that has the best execution on the testing test.

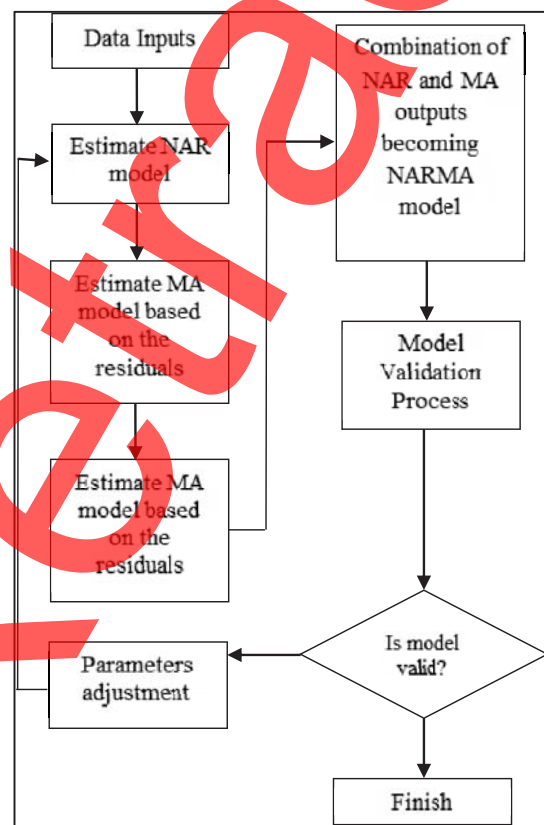


Figure 6. Experiment flowchart

Table 2. Neural network parameter adjustment

Parameter Adjustment			
NAR	NARMA		Hidden Nodes
Input Lags	Input Lags	Error Lags	
5, 10, 15, 20, 25, 30, 35, 40	5, 10, 15, 20, 25, 30, 35, 40	5, 10, 15, 20, 25, 30, 35, 40	5, 10, 15, 20, 25, 30,35, 40

5. Results and Discussions

The novelties of this research are implementation of the neural network in NARMA model on the muscle force data. This paper developed quadriceps muscle model by using artificial intelligent technique called backpropagation NN-NARMA. The performance of model most optimally tuned set of parameter has been evaluated and it give the better accuracy. Based on the results in Table 3, it is found that the optimal configuration of BPNN-NARMA for the muscle force data is 20-20-20, with RMSE for training set (0.063), validation set (0.067) and testing set (0.059). This can be proven by the shortest bar in Figure 7. It can be clearly seen that the RMSE values of all different sets are almost similar or parallel, which means that the results are relevant. The parameter found in this study is possible to be used to control various strategies in FES system to provide rehabilitation for stroke patients.

Acknowledgment

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Figure 7. Comparisons of RMSEs of different network configurations by different sets. (a), histogram and (b), radar diagram

Table 3. RMSES of testing sets by different network configurations

Network Configuration (IL,EL,H)	NAR	NARMA	PSO-NAR	PSO-NARMA
(10,10,10)	0.11987	0.11371	0.01363	0.01293
(10,10,15)	0.11878	0.12887	0.01531	0.01661
(10,10,20)	0.10685	0.12197	0.01303	0.01488
(10,10,25)	0.10049	0.15656	0.01573	0.02451
(10,10,30)	0.09553	0.15148	0.01447	0.02295
(10,10,35)	0.13826	0.20319	0.02809	0.04129
(10,10,40)	0.08170	0.15274	0.01248	0.02333
(15,15,10)	0.12694	0.10343	0.01313	0.01070
(15,15,15)	0.09819	0.09155	0.00899	0.00838
(15,15,20)	0.09340	0.11451	0.01070	0.01311
(15,15,25)	0.09754	0.12426	0.01212	0.01544
(15,15,30)	0.07529	0.11967	0.00901	0.01432
(15,15,35)	0.08812	0.14335	0.01263	0.02055
(15,15,40)	0.10951	0.16410	0.01797	0.02693
(20,20,10)	0.09560	0.13731	0.01313	0.01885
(20,20,15)	0.10665	0.13887	0.01481	0.01929
(20,20,20)	0.05876	0.06586	0.00387	0.00434
(20,20,25)	0.11264	0.13235	0.01491	0.01752
(20,20,30)	0.07864	0.16155	0.01270	0.02610
(20,20,35)	0.10905	0.15720	0.01714	0.02471
(20,20,40)	0.22065	0.25844	0.05702	0.06679
(25,25,10)	0.08951	0.06042	0.00541	0.00365
(25,25,15)	0.08679	0.12007	0.01042	0.01442
(25,25,20)	0.07076	0.07399	0.00524	0.00547
(25,25,25)	0.09166	0.12575	0.01153	0.01581
(25,25,30)	0.07525	0.11587	0.00872	0.01343
(25,25,35)	0.07719	0.12620	0.00974	0.01593
(25,25,40)	0.07220	0.11061	0.00799	0.01224
(30,30,10)	0.11985	0.13432	0.01610	0.01804
(30,30,15)	0.06832	0.08846	0.00604	0.00782
(30,30,20)	0.09413	0.15214	0.01432	0.02315
(30,30,25)	0.09040	0.14842	0.01342	0.02203
(30,30,30)	0.08727	0.13984	0.01220	0.01956
(30,30,35)	0.08987	0.13478	0.01211	0.01816
(30,30,40)	0.08239	0.18610	0.01533	0.03463
(35,35,10)	0.10504	0.11571	0.01215	0.01339
(35,35,15)	0.10569	0.14146	0.01495	0.02001
(35,35,20)	0.08913	0.15777	0.01406	0.02489
(35,35,25)	0.08076	0.11205	0.00905	0.01256
(35,35,30)	0.05435	0.12635	0.00687	0.01597
(35,35,35)	0.08808	0.17467	0.01538	0.03051
(35,35,40)	0.10012	0.15881	0.01590	0.02522
(40,40,10)	0.06262	0.07016	0.00439	0.00492
(40,40,15)	0.05594	0.08974	0.00502	0.00805
(40,40,20)	0.07944	0.10512	0.00835	0.01105
(40,40,25)	0.06077	0.12707	0.00772	0.01615
(40,40,30)	0.07240	0.14652	0.01061	0.02147
(40,40,35)	0.09135	0.15661	0.01431	0.02453
(40,40,40)	0.07377	0.15243	0.01124	0.02323

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