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INDUSTRIAL AND SYSTEMS ENGINEERING GRADUATE PROGRAM - PPGEPS

LOW-COST PROTOTYPE DEVELOPMENT AND SWIM VELOCITY PROFILE IDENTIFICATION USING NEURAL NETWORK ASSOCIATED TO GENERALIZED EXTREMAL OPTIMIZATION

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Presentation outline

1. Introduction;
2. Velocity measurement prototype for swimming;
3. Swim velocity profile identification;
   - Radial Basis Function Neural Network;
   - Generalized Extremal Optimization.
4. Prototype tests and results;
5. Conclusions.

1. Introduction

Problem Statement:

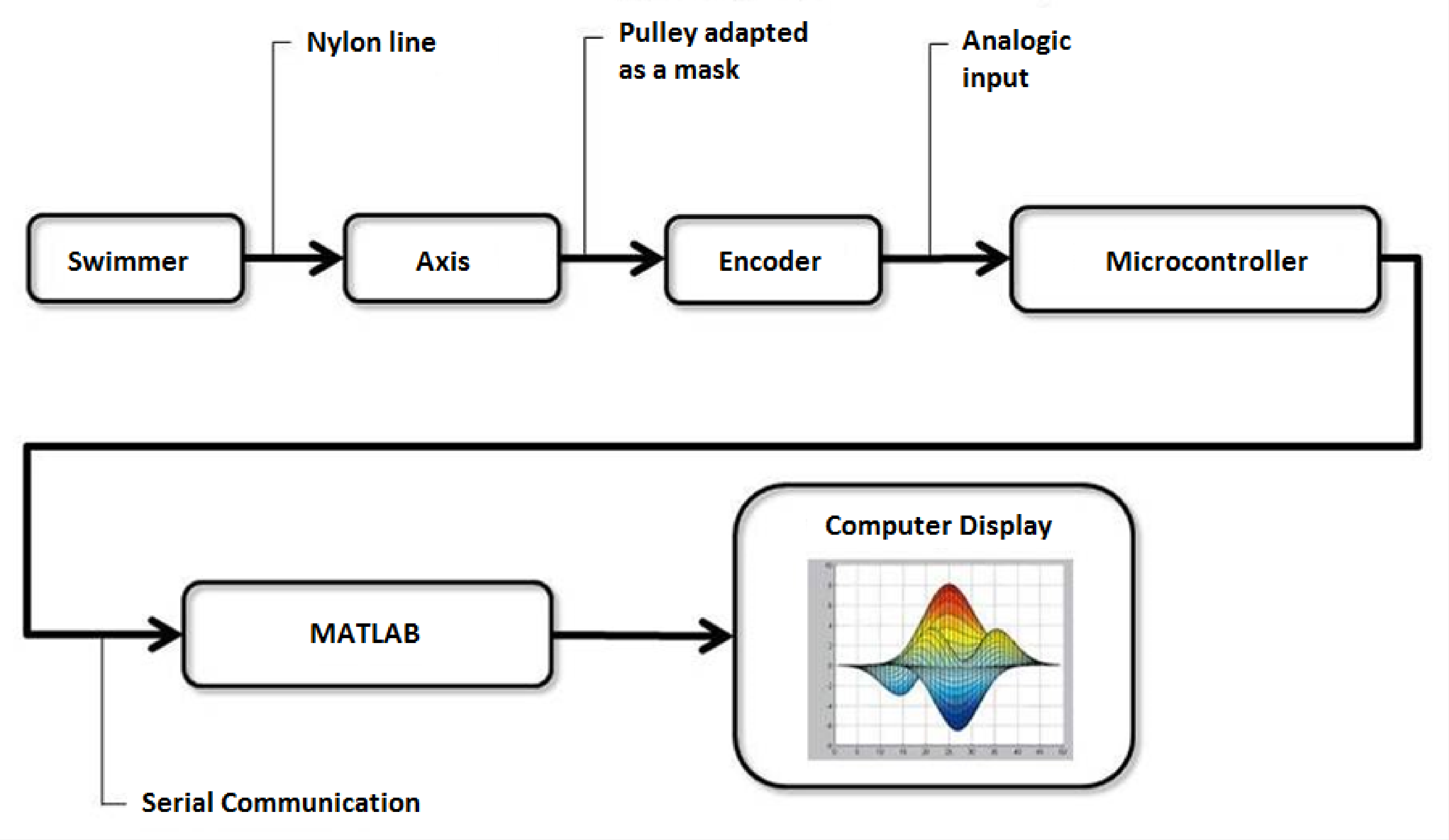
By the interaction of propulsive and resistive forces, velocity can be increased and many research works in the competition area are considering this important variable to investigate the athletes' performances (Toussaint, 2002; Havriluk, 2004; Wakayoshi, et al., 2010; Arellano et al., 2010; Stamm et al., 2011; Coelho et al. 2013).

1. Introduction

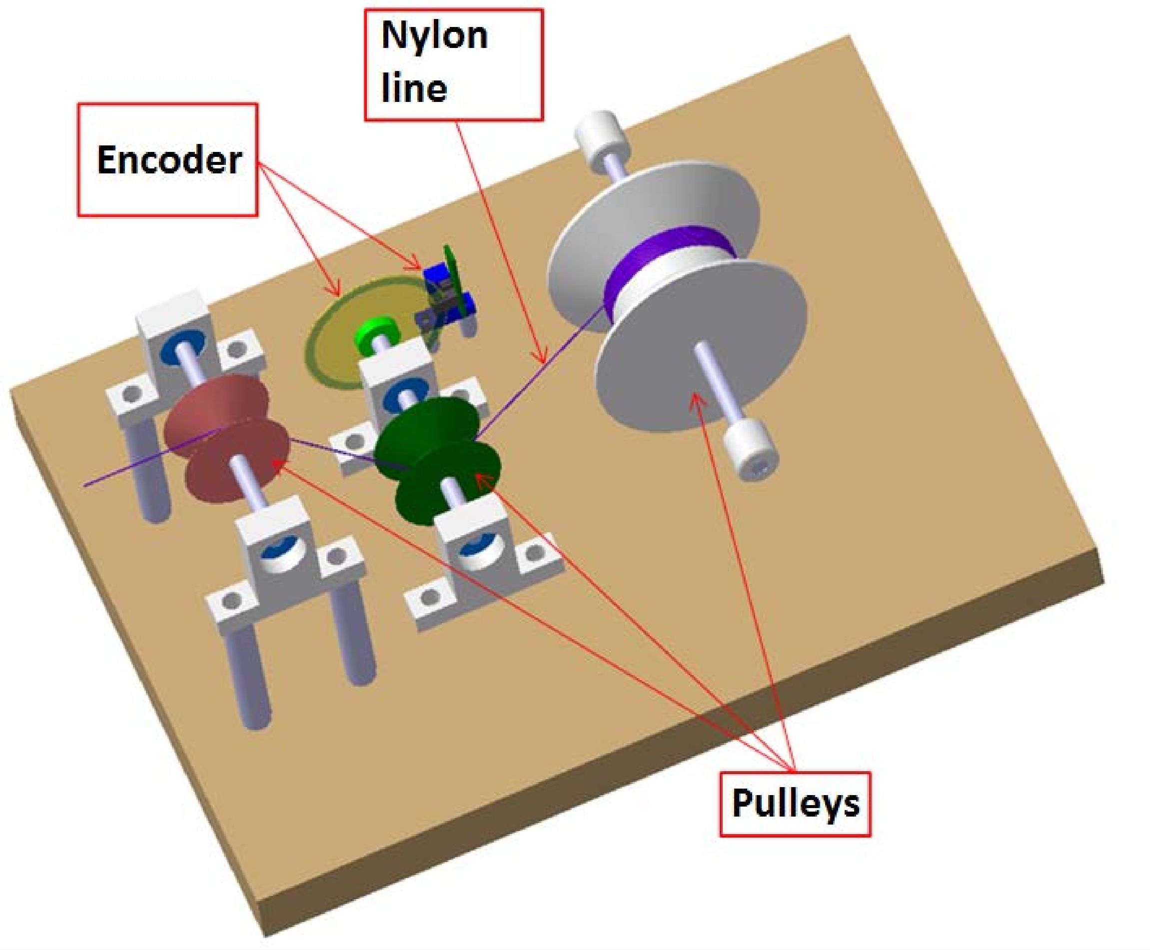
Motivation:

- After the city of Rio de Janeiro became a candidate city for the 2016 Olympic Games resources for research emerged from both Government and swim teams in Brazil;
- PUCPR provides tre ining structure for athletes and parathletes.

2. Velocity measurement prototype for swimming



2. Velocity measurement prototype for swimming



2. Velocity measurement prototype for swimming

3. Swim velocity profile identification

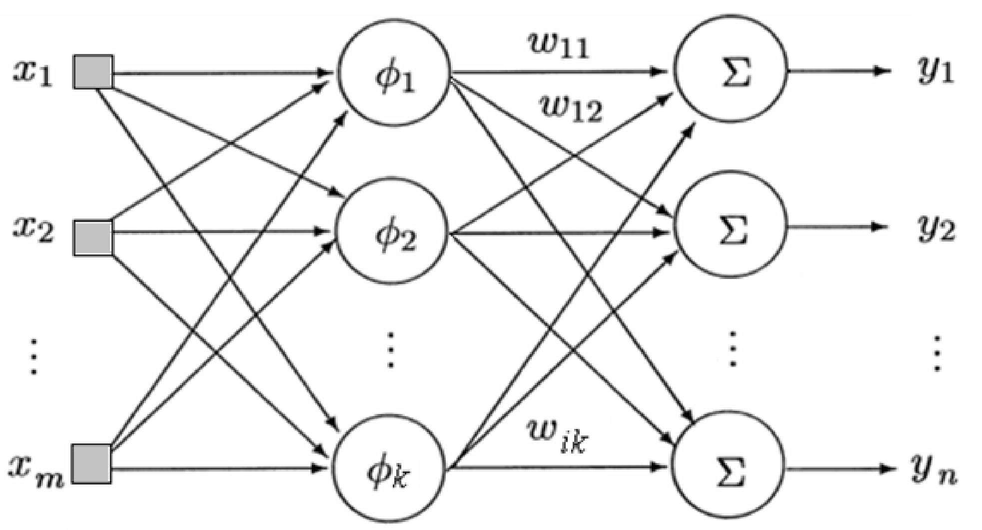
Many identification techniques can be used to provide information about the athletes' performance.

→**Radial-Basis Function Neural Network**

- Three-layered network;
- The input nodes provide the input values to the internal nodes that formulate the hidden layer.

3.1. Radial Basis Function Neural Network

To provide desirable results some parameters of the RBFNN must be set:



$$\phi_j(\boldsymbol{x}) = \exp\left\{ -\frac{\left\| \boldsymbol{x} - \boldsymbol{\mu}_j \right\|^2}{\sigma_j^2} \right\}$$

$$y_i = \sum_{j=1}^{k} w_{ij} \cdot \phi_j(\boldsymbol{x})$$

3.2. Generalized Extremal Optimization

- GEO (Sousa et al., 2004) was used to adjust the Gaussian basis function width σ_j.
- In order to provide the best curve fitting as possible, in this case, the Multiple Correlation coefficient R^2 was adopted as the maximization problem:

$$R^2 = 1 - \frac{\sum_{t=1}^{Ns} [y(t) - \hat{y}(t)]^2}{\sum_{t=1}^{Ns} [y(t) - \bar{y}]^2}$$

4. Prototype tests and results

Data aquisition:

- 25 meters swimming pool;
- Brazilian elite male swimmer in crawl stroke;
- The crawl stroke velocity analysis has been selected due to its non-linear time series behavior providing challenging data for the identification technique.

4. Prototype tests and results

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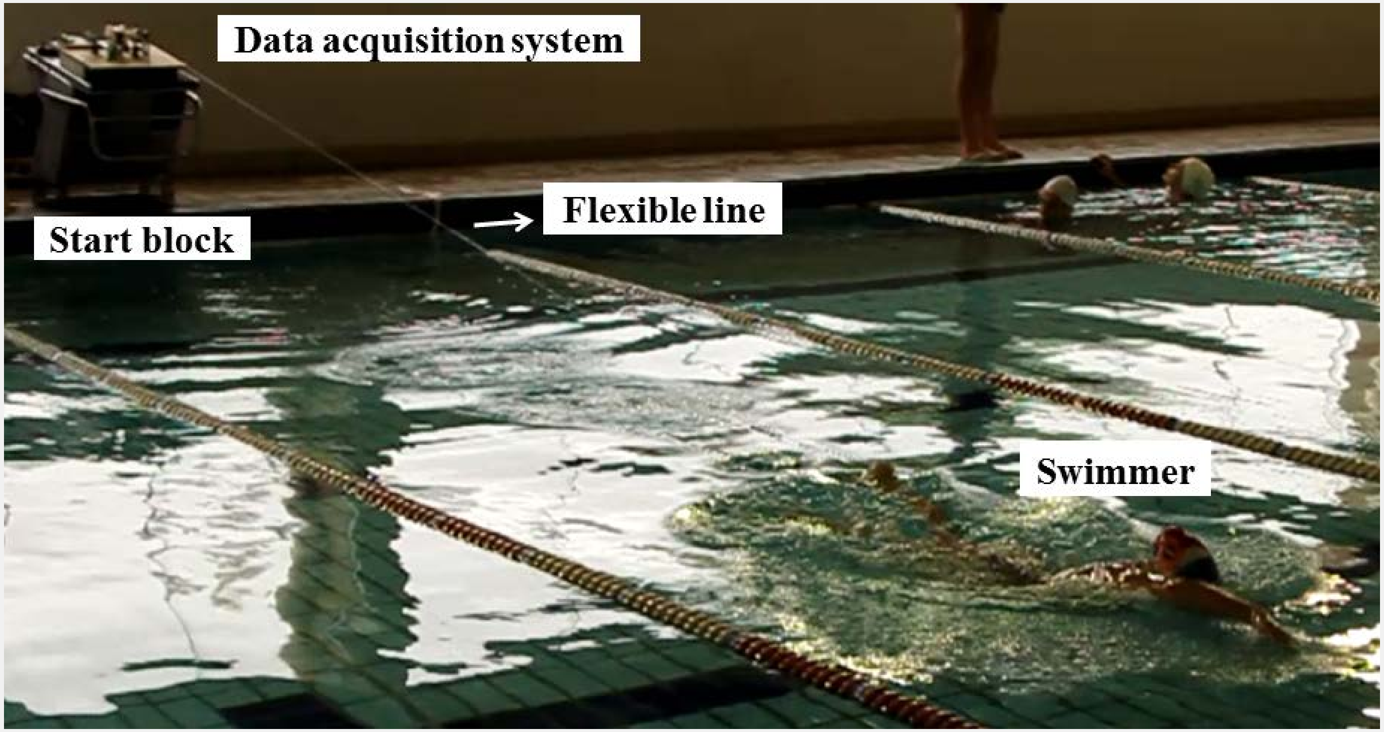
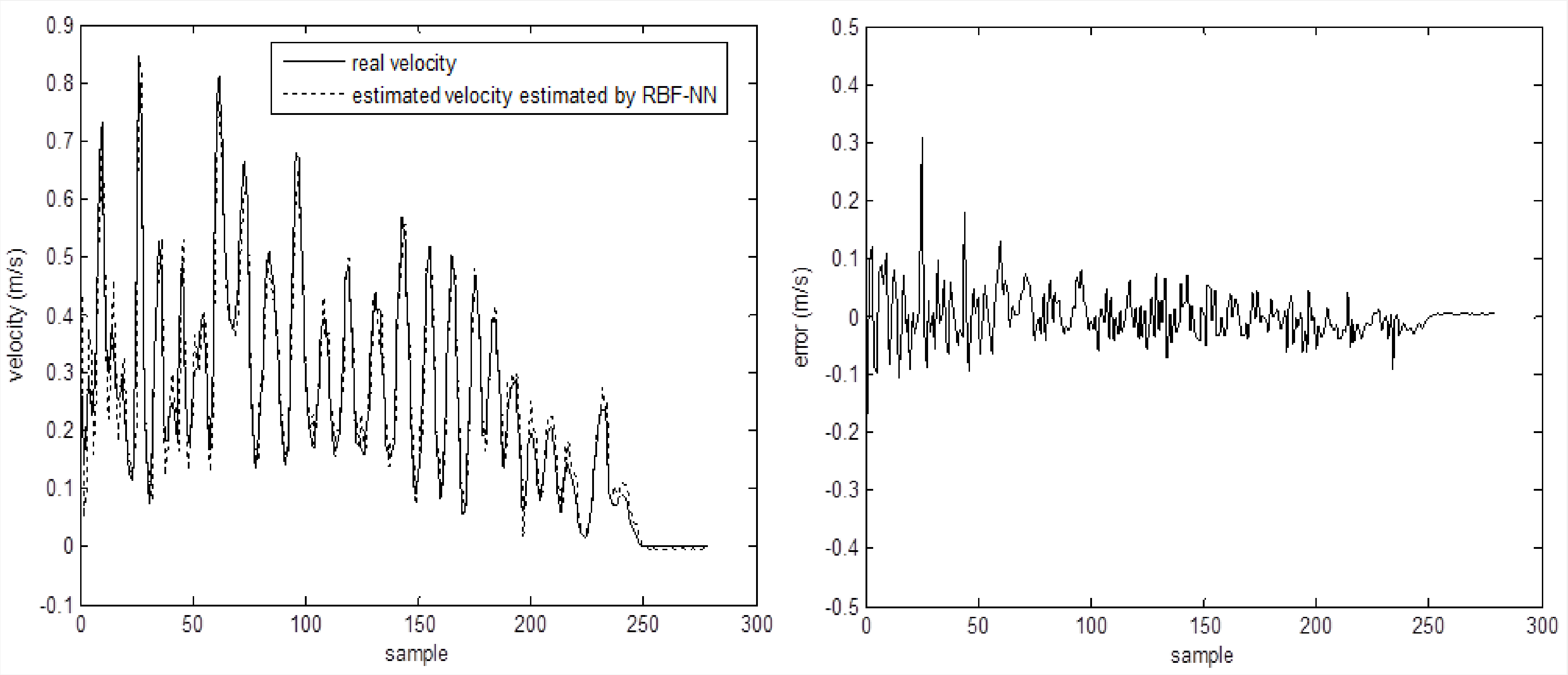
280 instantaneous velocity samples have been used, where 210 and 70 samples were adopted for the estimation and the validation phases, respectively.



4. Prototype tests and results

	R^2 Values	
Number of Gaussian functions	Estimation phase	Validation phase
2	0.000000	0.000000
3	0.153205	0.154444
4	0.309637	0.308260
5	0.691360	0.688809
6	0.696919	0.733940
7	0.834789	0.839550
8	0.809682	0.814550
9	0.885857	0.884950
10	0.884779	0.885116
11	**0.902105**	**0.900993**
12	0.901095	0.898873

4. Prototype tests and results



5. Conclusions

- An identification procedure by using velocity data of Brazilian elite male swimmer in crawl stroke have been obtained into a 25 meters test and a black-box model, capable to provide the athlete velocity, was found and validated;
- Future works are directed to evaluate new identification techniques in swimming time series forecasting, to improve the prototype precision and increase the number of samples per second and enhance the software performance by including video synchronization.

Acknowledgement

CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico

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