ASSAY FOR ROUTE RECOGNITION BY NEURAL NETWORK

ANDRÉ LUIZ DA SILVA DIAS

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ADVISOR:
PROF. JOSÉ GOMES DE CARVALHO JUNIOR

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Objective

» Large vessels use radars to guide their operations. The information obtained must be interpreted. The ability to interpret and anticipate relative positions between vessels makes it possible to predict maneuvers, increasing safety conditions or allowing for anticipated strategic solutions.

» The objective of this essay is to study the possibility of interpreting the kinematic behavior of large vessels using artificial neural networks.

Current Techniques

Traditionally, when predicting target behavior, the Kalman Filter is used to estimate position and velocity and make them available for the rest of the system to use conveniently, such as calculating the target's heading.

Long Term Purpose

Use ANNs as an alternative to Kalman Filters in predicting the next position or a hybrid system that improves the performance of the current system used in the Radar Extractor.

The Radar Extractor

The Navy implemented a national target tracking system – the Radar Extractor, with the participation of its technical team and with external consultancy to the Navy for the implementation of a tracking filter (Kalman filter). This system was part of the Tactical Control System – SICONTA, entirely developed in Brazil, which equipped the former aircraft carrier Minas Gerais for a few years.

Radar & GAR Extractor

In parallel with the development of the Radar Extractor, a radar target simulation system was developed that allowed the use of the Radar Extractor in the laboratory without the use of a real radar, facilitating the continuity of its development. This simulator is called GAR – Radar Target Generator.

Research Method

We assume that, if we can guarantee the possibility of recognizing sections of a trajectory by an ANN, we will have taken the first steps towards predicting it, since one thing does not occur without the other, as it is difficult to imagine the possibility of predicting something that we cannot even recognize.

Proposta do Trabalho

Como todo ensaio, ele procura, partindo de conceitos simples, evoluir para os mais complexos, obedecendo a escala gradativa do estudo da complexidade de um fenômeno. Desta forma, vamos abordar neste trabalho a possibilidade de RNAs diferenciarem trechos curvilíneos de retilíneos em uma trajetória de um alvo rastreado por radar. Acreditamos que se pudermos estabelecer um método fundamentado, estaremos contribuindo para soluções futuras sobre esta temática.

O projeto

- O projeto, denominado Rastreador, é um software composto por 3 módulos integrados. São eles:
  - Gerador de Rotas
  - Conversor de Dados
  - Analisador de Rotas

The Route Generator

Given the need to obtain simulations of the model, and not having the resources previously mentioned, we created a simplified simulator for uniform movements that met the exclusive purposes of our work, allowing us to generate routes using a script, with noise generation and modulation resources.

The Data Converter

It allows a comparison of the improvements that could result from replacing the initial format of the data, provided in two-dimensional orthogonal Cartesian coordinates, with polar Cartesian coordinates. These conversions can be performed using several different processing criteria that will be useful in the future in the continuation of the work. The discussion of these conversion methods is detailed in the appendix.

The Route Analyzer

- It is responsible for analyzing the issue proposed here. This module uses dynamic artificial neural network analysis methods.
- They have several configuration features.
- The current version only covers Elman Networks, which is sufficient for our purposes.

Why Elman Networks?

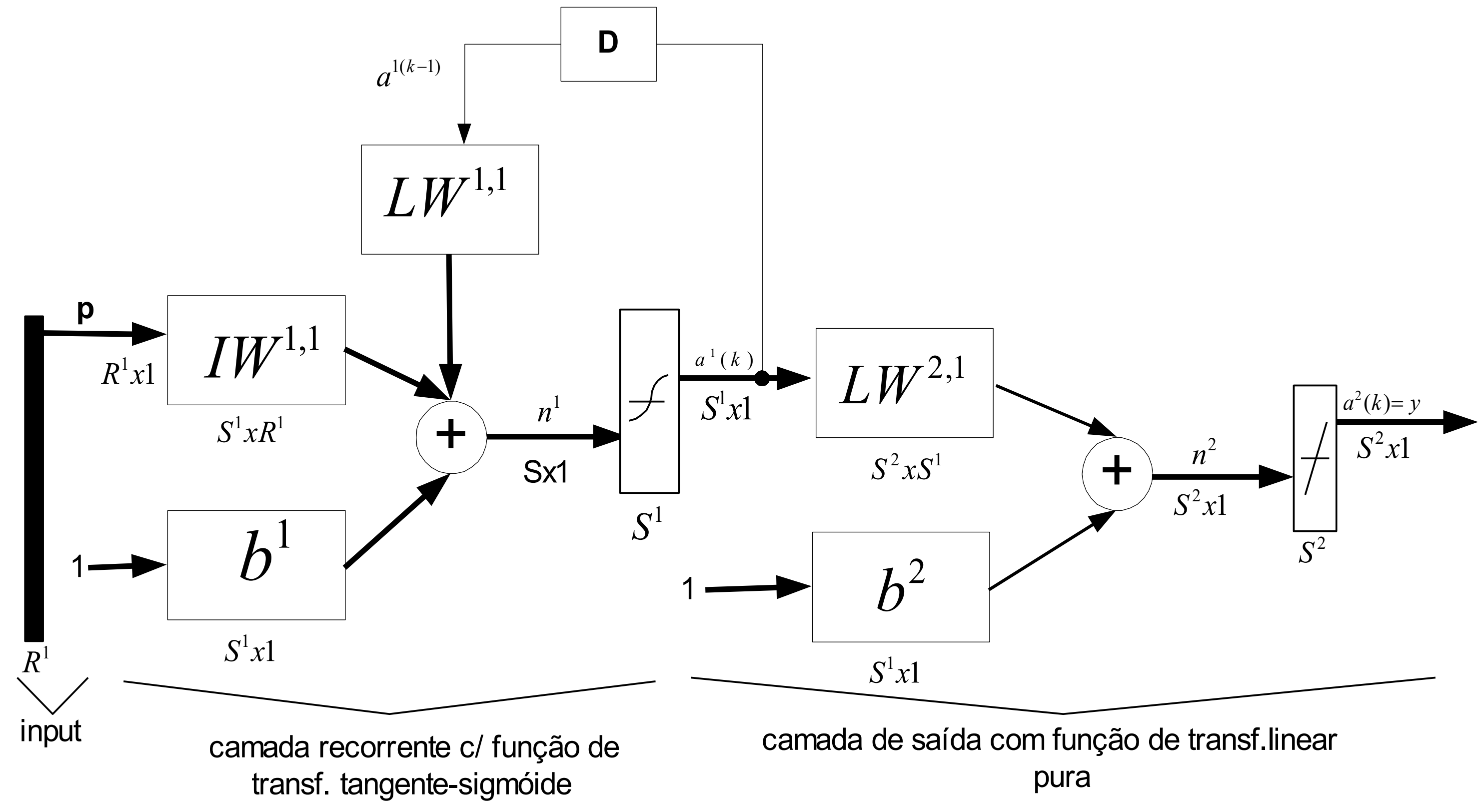
- Since the movement of a mobile is a succession of states over time, we can then treat it using temporal processing.

- From our perspective, recurrence is a fundamental characteristic, the reason we adopted Elman networks because these are real-time recurrent networks.

Topology of an Elman Network

Its topology is formed by two layers with backpropagation and the addition of a feedback connection from the hidden layer output to its input, which allows the Elman network to learn to recognize and generate temporal patterns, as well as spatial patterns. (Elman, J.L.; Cognitive Science: Finding Structure in Time, vol.13. pp-179-211,1990.)

Elman Network - Diagram



$$a^1(k) = \tan sig(IW^{1,1}p + LW^{1,1}a^{1(k-1)} + b^1$$

$$a^2(k) = purelin(LW^{1,1}p + LW^{2,1}a^{1k} + b^2$$

Procedure Adopted

1 - Simulate the trajectory of a noise-free target (ideal circumstances).

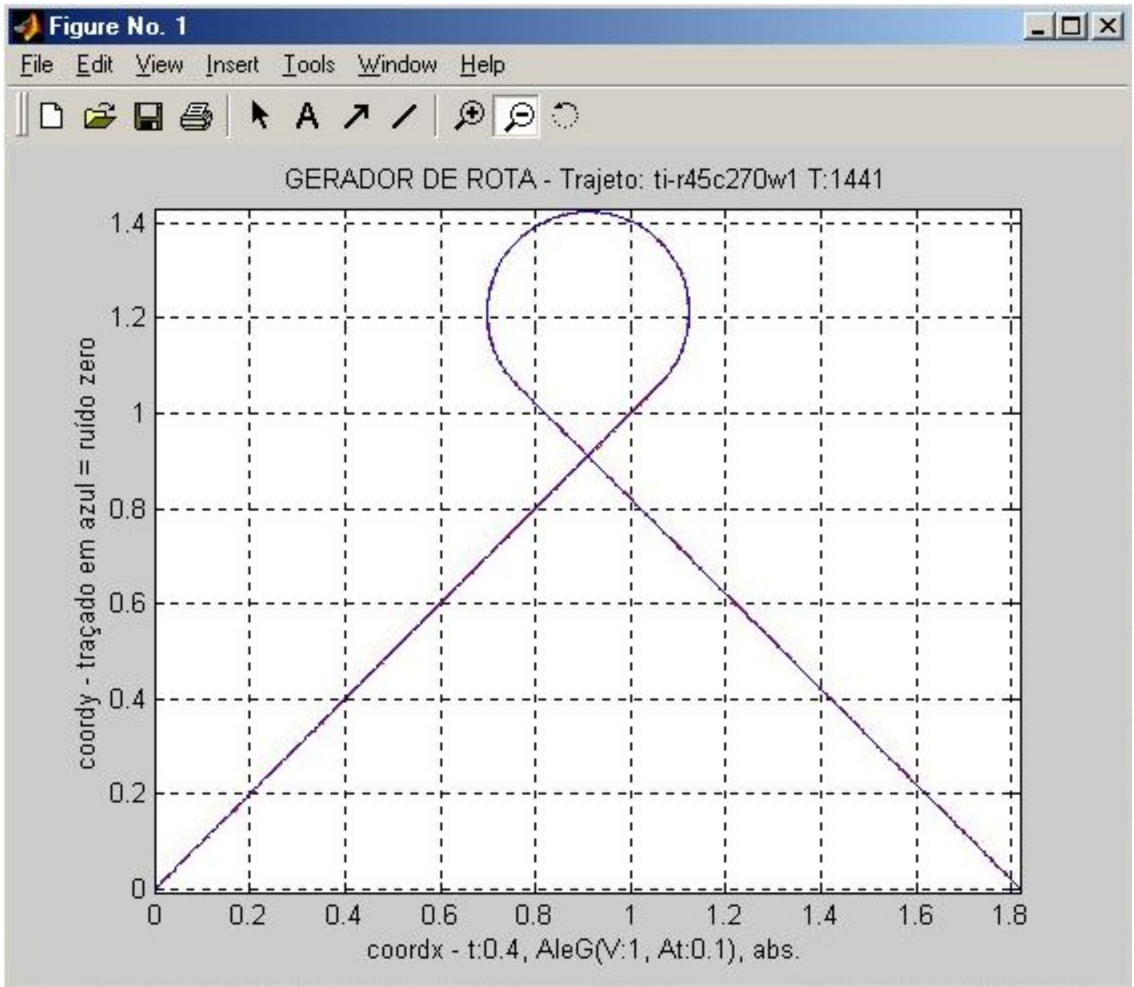
2 – Verify the result of the behavior of an ANN in differentiating straight sections from curvilinear ones.

3 – Optimization of the results.

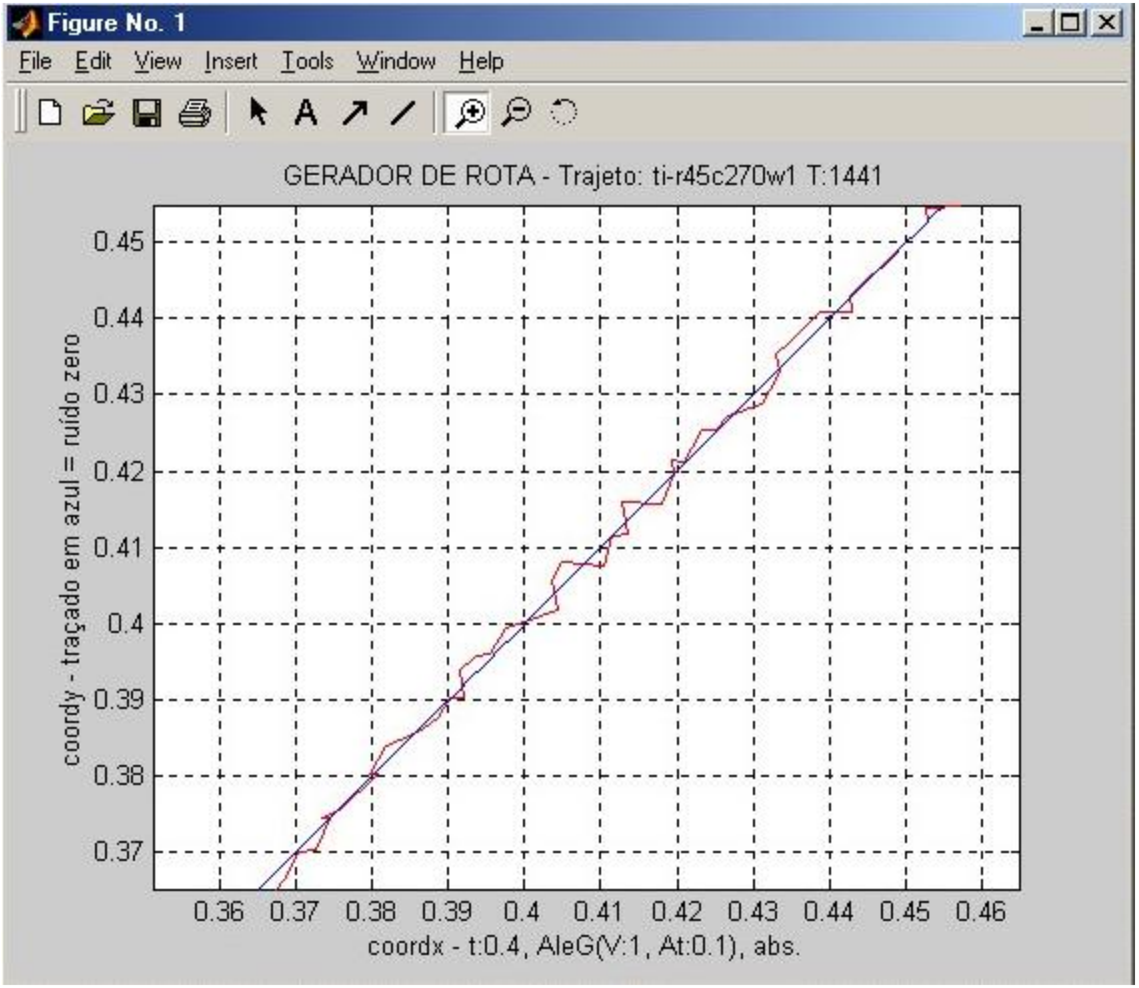
4 - Test results under adverse conditions generated by noise (real circumstances).

5 - If successful, evaluate the generalization capacity of the ANN.

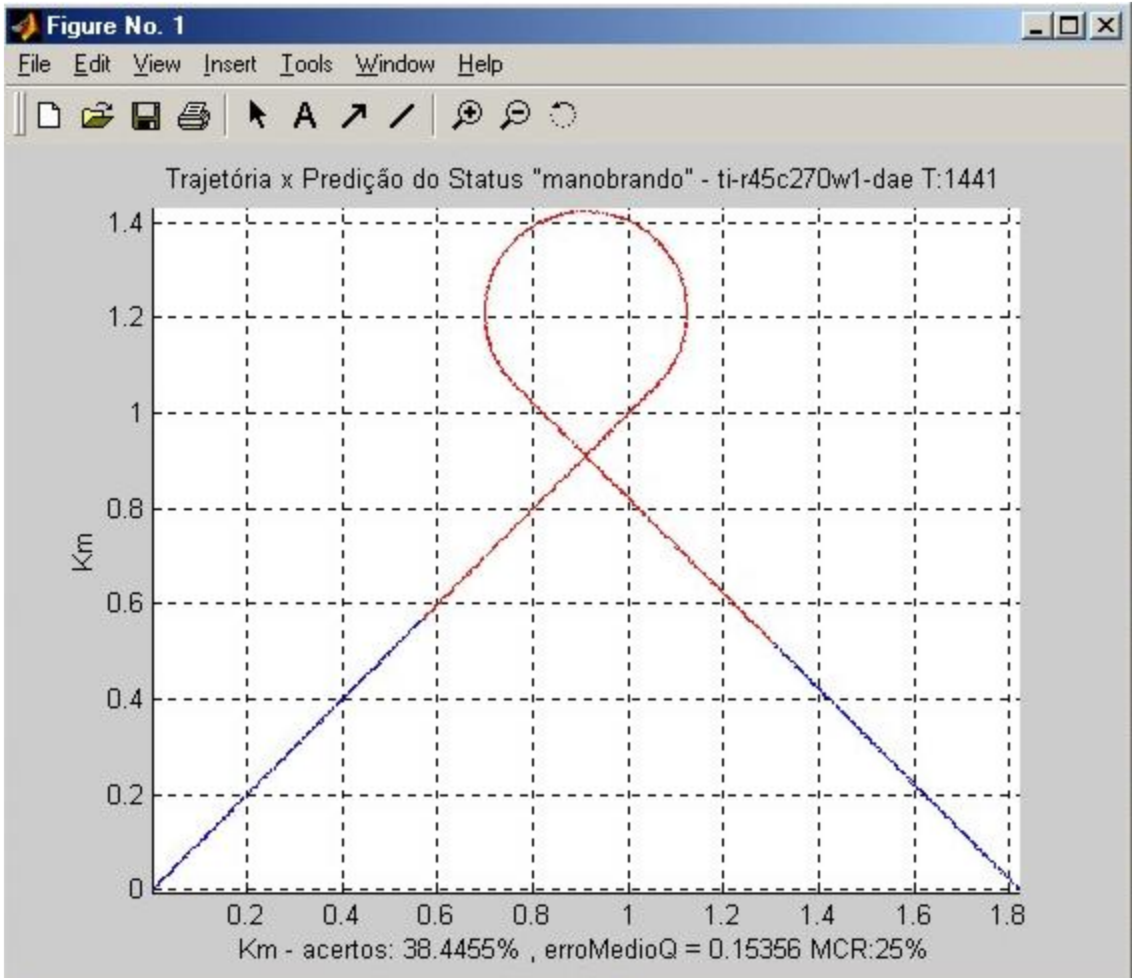
Noisy Generated Route



Noise Detail



Initial Result



Recognizing the Trajectory

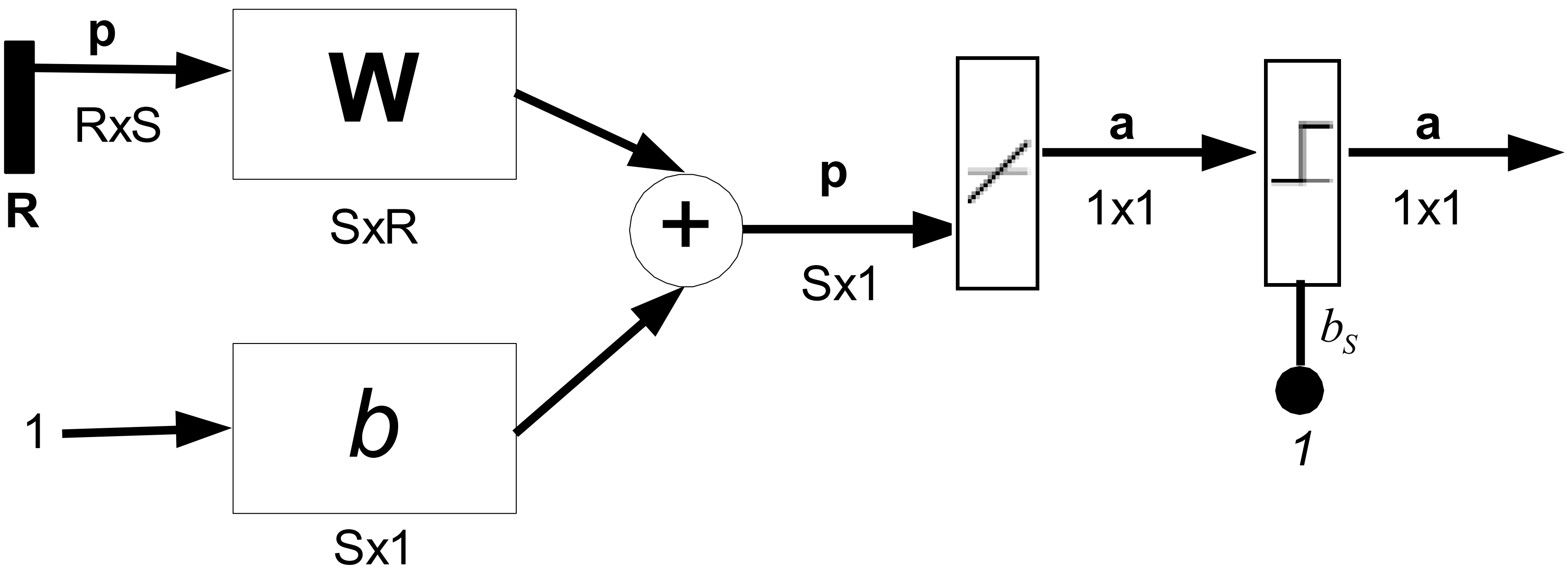
- How does the neural network in our essay perform its task?

- Since the adopted topology uses a linear function (see fig. 1), we need to define a margin for the criticism of results. Let's suppose, for example, that one output value generated is equal to 0.95 and another to 0.85? If we consider both correct, then we are considering a tolerance margin of 5% and 15%, respectively, for the criticism of the results. We can consider this tolerance as the “critical margin of results” (MCR).

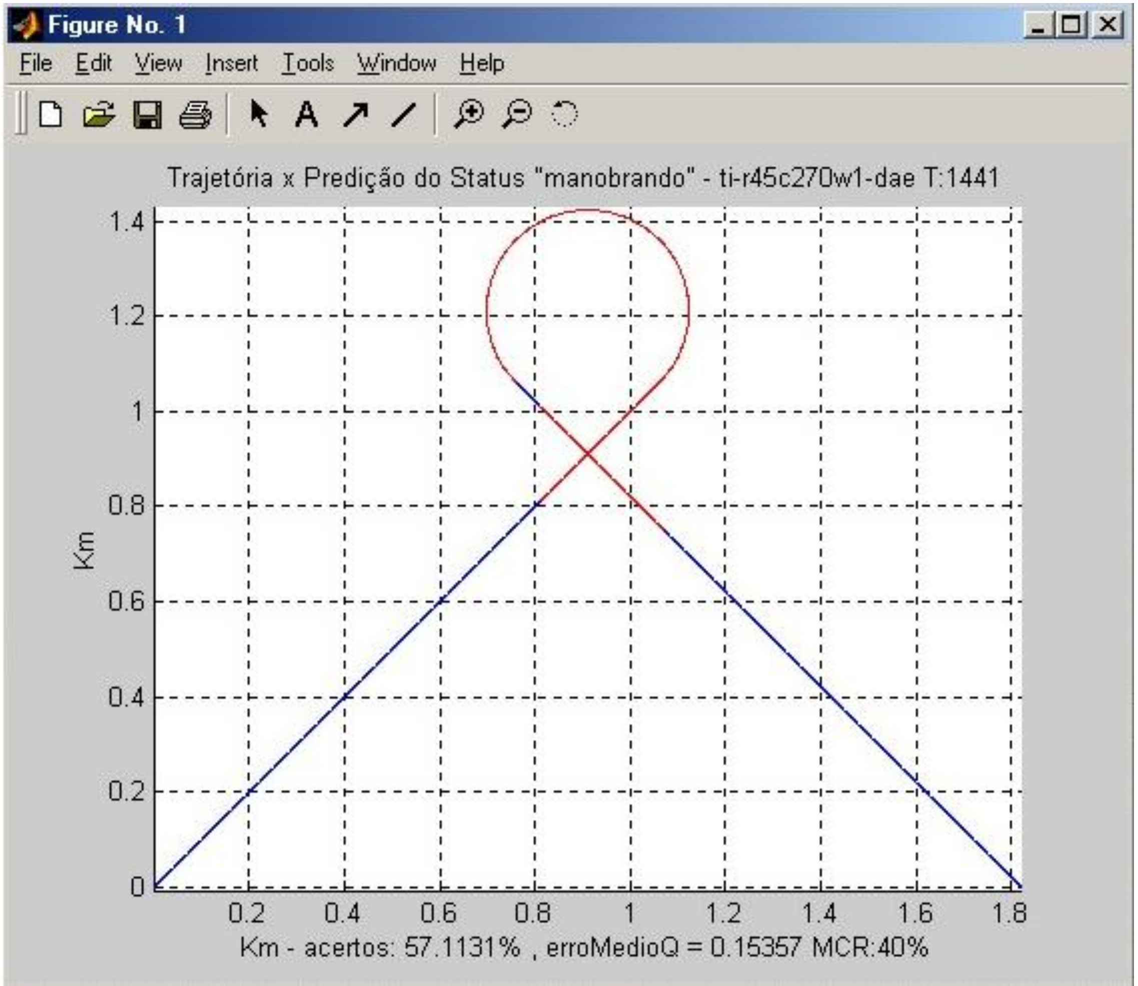
How Does The MCR Work?

The MCR is actually a threshold activation function, placed in series with the first activation function which is of the linear type, generating a new topology, which can be analyzed in the following diagram.

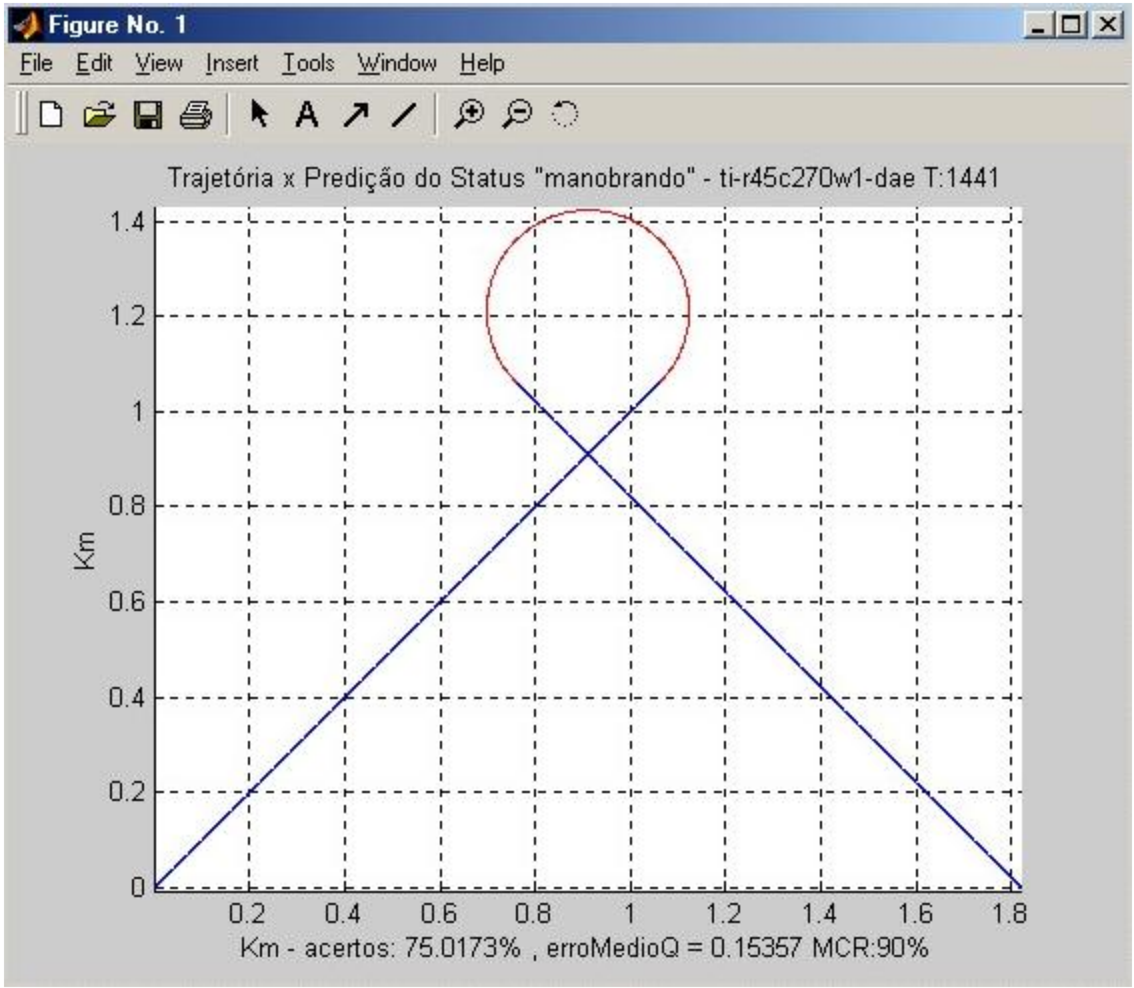
Final Topology Diagram



Example with MCR=40%



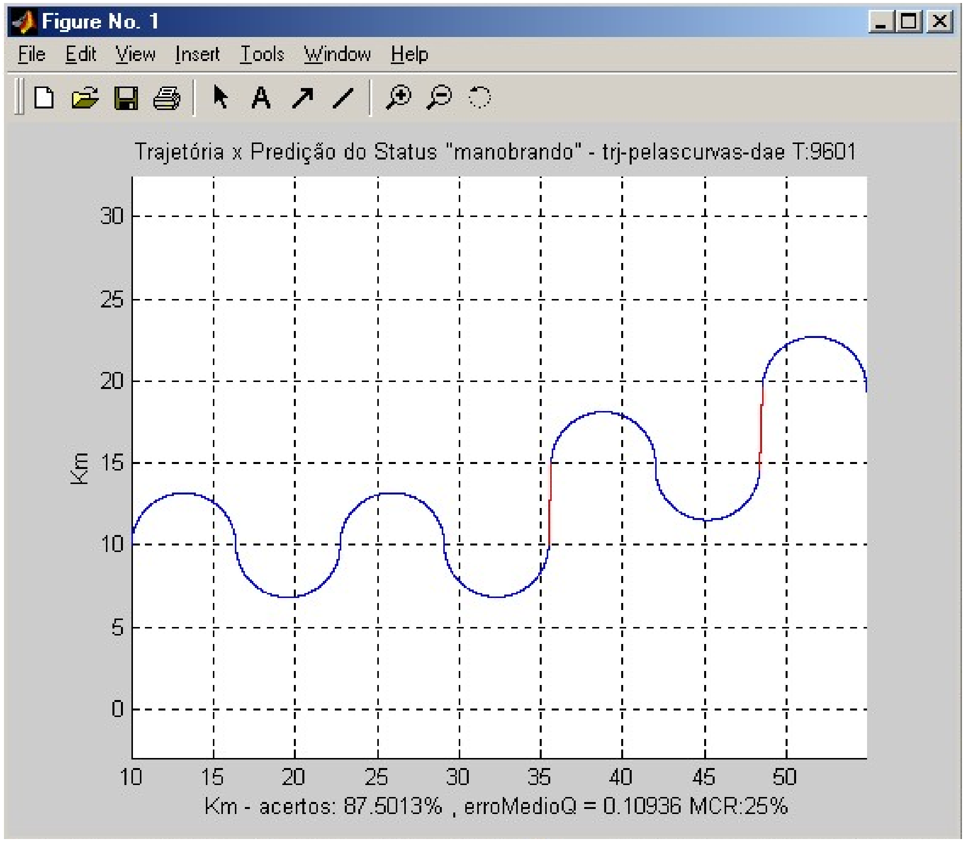
Example with MCR=90%



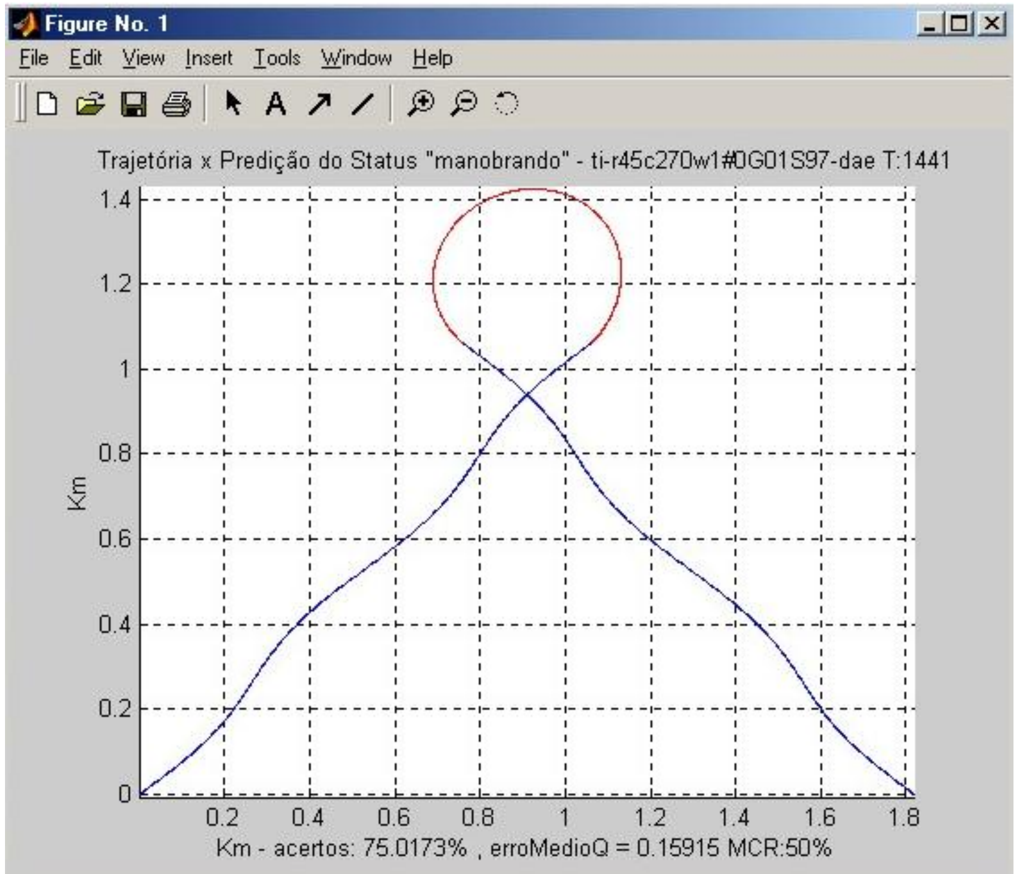
Interpreting the Network

The network adjusts its weights and obtains the decision equation by reading the initial section of the path, since it provides the first data received by it, which is then dynamically updated as it travels along the path. The network “learns” the decision equation from the first pattern formed.

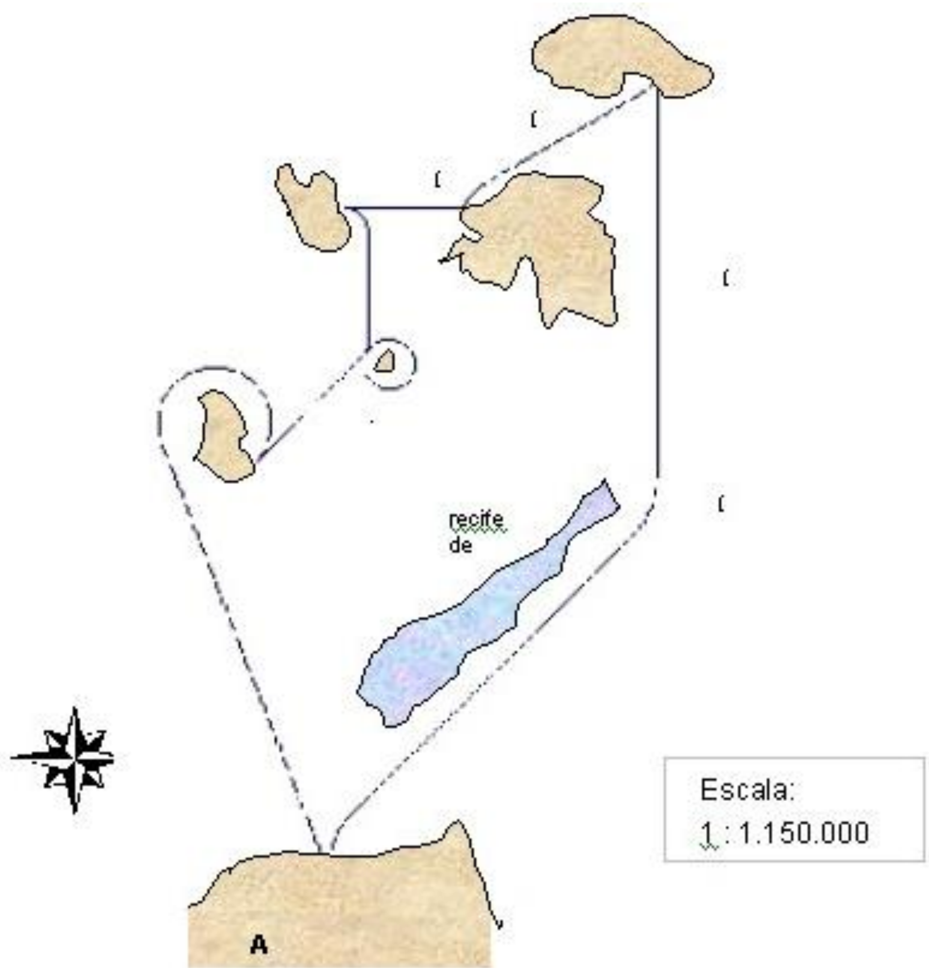
Interpreting The Network Example



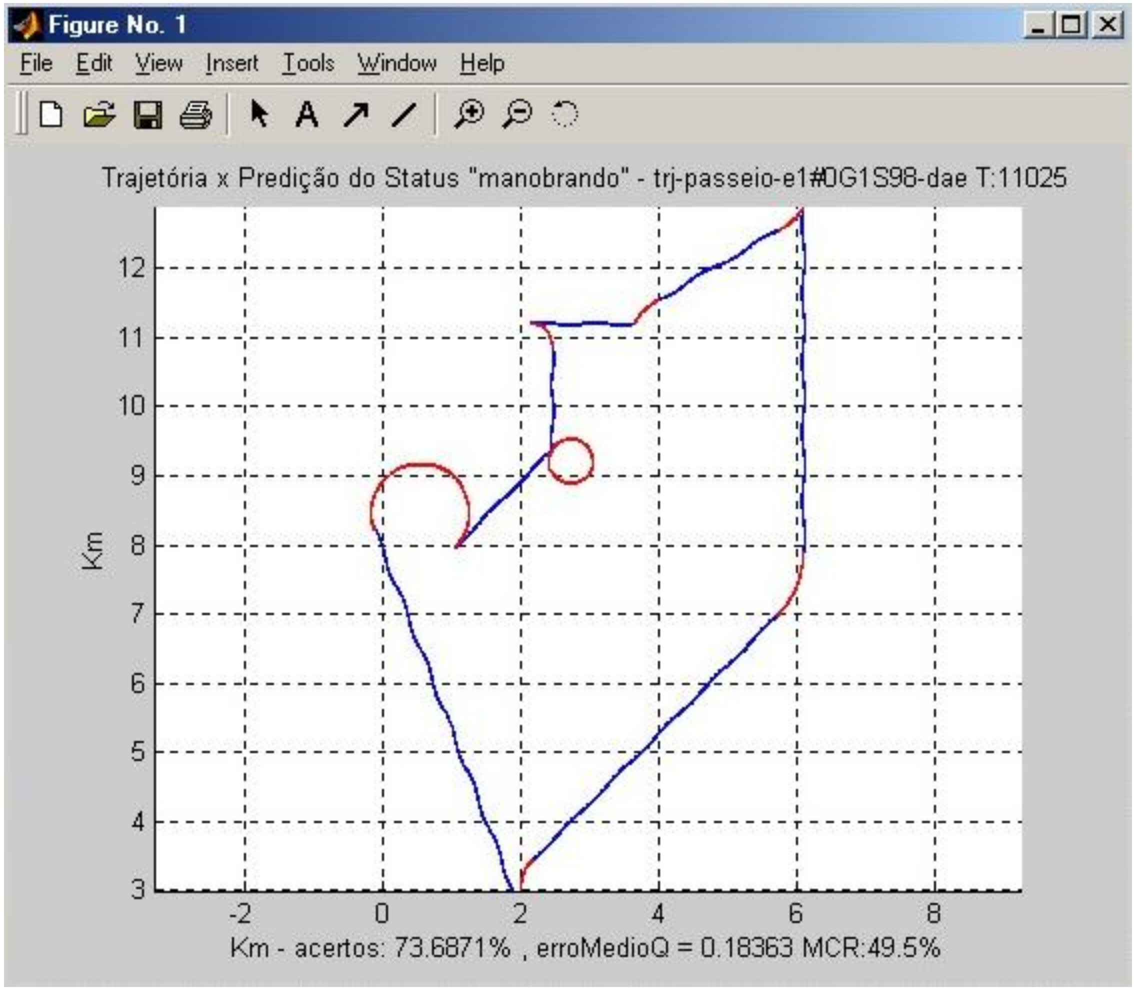
And curves x curves?



A Real Case



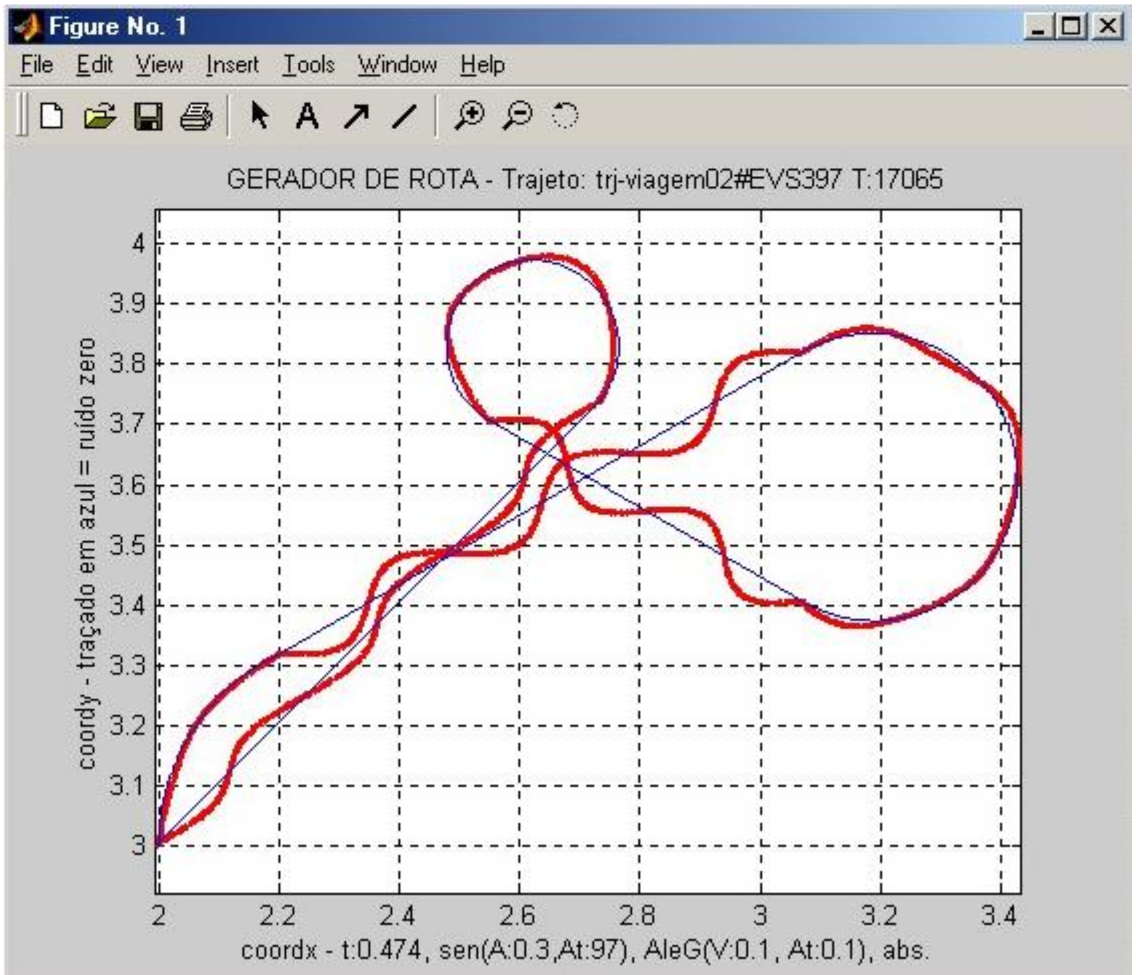
Result with Noise and Modulation



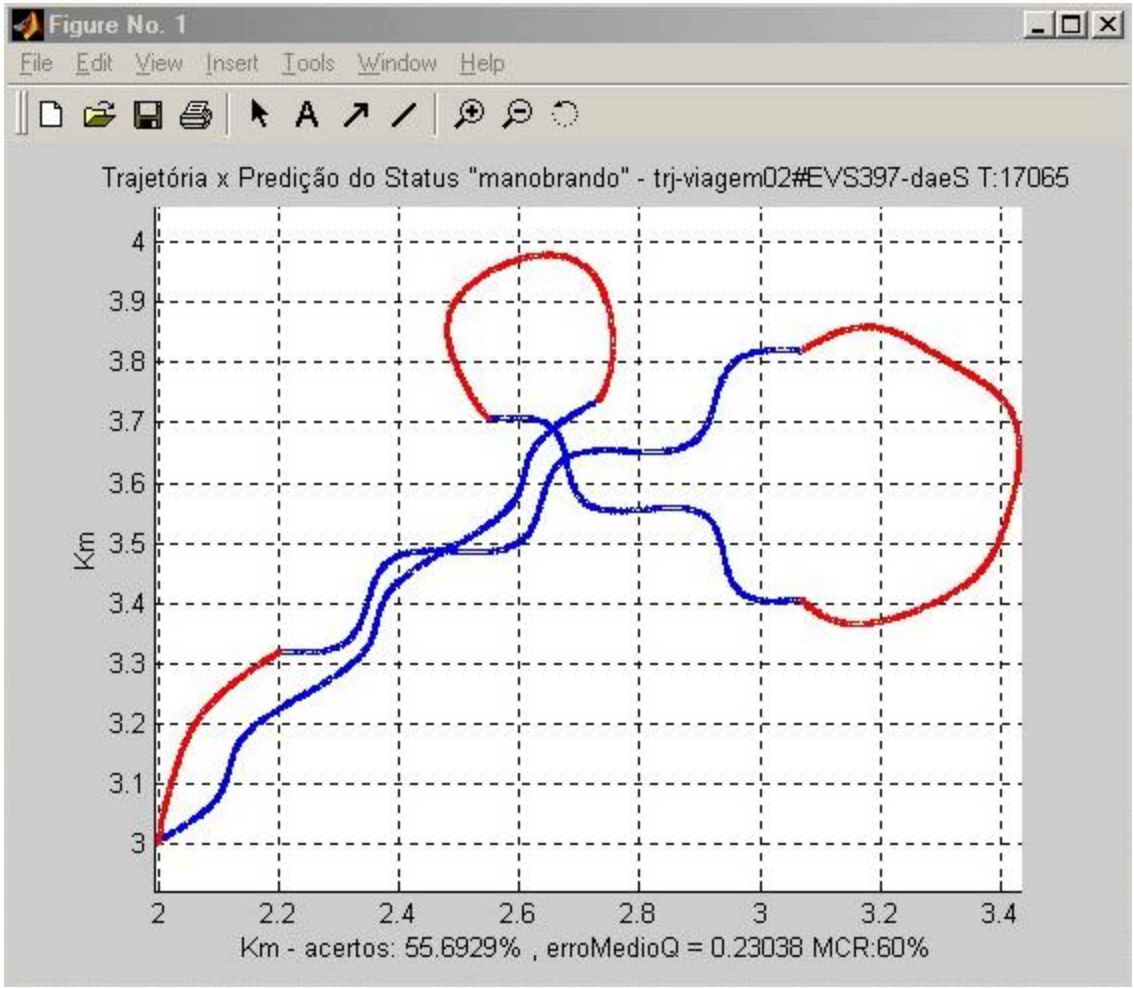
TESTING THE NETWORK

- We created two files, originating from the same script, the first of which is free of any noise, assuming ideal conditions.
- Then, we generate a second file, from the same script file, introducing so many deformations that the final result becomes quite distant from the original.

Rota de Treino x Teste (vm)



Final Result



Conclusão

- RNA can recognize sections of trajectories, differentiating kinematic behaviors.
- They can do so under adverse circumstances of noise and oscillations inherent to the movement.
- They have good generalization capacity.