Advances of Neural Networks in Sports Science

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Outline

Sports Science
Artificial Neural Network
Importance of ANN
Application of ANN is Sports Science
  • Modeling a swimming performance
  • Movement variability analysis by SOMs
  • Dynamical System analysis
Future Research
Conclusion
Sports Science

Application of scientific principles and techniques with the aim of improving sporting performance.
Artificial Neural Networks

Neural Network - Information processing paradigm inspired by biological nervous systems, such as our brain.

Structure - Large number of highly interconnected processing elements.

Neurons – Working together.

- Axon (Carries signals away)
- Nucleus
- Dendrites (Carry signals in)
- Synapse size changes in response to learning

\[ x = \sum_{j=1}^{N} W_j I_j \]

\( x > T \) -> \( S \)
Importance of ANN in Sports Science

- Qualitative analysis
- Pick out the structure from existing data.
- Non-linear analysis
- Study the behaviour of an evolving dynamical system
Application of ANN in sports science

• **Data Analysis** (Pattern recognition or data classification through a learning process)

• **Model a performance**

• **Predict performance** (learning from past experience)

• **Identify talent**

• **Human movement variability**

• **Dynamical sports scene**

• **Decision making**
Modeling a swimming performance

Inspiration from Cybernetics - Ştefan Odobleja (1902–1978)

Earlier research models - Fourier analysis, Coherent State analysis.

Parameters - Kin anthropometric evaluation
- Functional evaluation
- Specific functional evaluation
- Semi-qualitative swimming technical evaluation

80% of data was used for training and 20% for validating

Modeling a swimming performance

Model – Multiple layer perceptron with a single hidden layer.

Modeling a swimming performance

Non linear function was optimized using Lavenberg-Maarquardt to minimize mean square error

\[ f(u) = \left( \sum_{j=1}^{k} v_{jl} \zeta \left( \sum_{i=1}^{n} w_{ij} \cdot u_i - \Theta_j \right) - \Theta_l \right), l = 1, \ldots, m \]

Weight Initialization – Decline method (Nguyen and Widrow, 1990)

\[ J = \frac{1}{2N} \sum_{k=1}^{N} (y(k) - \hat{y}(k))^2 \]

Pattern Error -

Results

• Male Swimmers
  • height correlated positively with the performance.
  • composition variables were correlated with performance.

• Female swimmers
  • the performance was correlated with chest depth, foot length, & height.
  • correlation between the lactate accumulation and performance

• General
  • Strength and performance was not much of significance.
  • Some correlations between performance and flexibility.

Results

• Deviations from predicted and actual result

• 4.64 seconds after 6 months
• 3.16 seconds after 18 months
• 3.03 seconds after 30 months

SOMs as a tool to measure movement variability

- Unsupervised learning – no target output
- Self-organization - Network organises based on the emergent collective properties of the input.
- Dimensionality reduction - Identify important features in the data by removing redundancy.

SOMs as a tool to measure movement variability

Time shifted at constant interval to represent the temporal nature of the data pattern
Self-organizing maps
Self-organizing maps

Output Layer

Input Layer

High-Dimensional Time Series Data
Self-organizing maps
Self-organizing maps
Self-organizing maps
Self-organizing maps
Self-organizing maps
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Self-organizing maps
Neighbourhood Function

Neighbourhood Radius

radius = 2
Neighbourhood Function

Neighbourhood Radius

radius = 2
Neighbourhood Function

Neighbourhood Radius

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Neighbourhood Function

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Neighbourhood Function

Neighbourhood Radius

radius = 2
Clear cells represent nodes in the output layer
Coloured Cell represent the distances between the neighbouring nodes in the output layer.
Blue cells represent short distances, while the red cells represent much larger distance.
Phase of the movement can be identified on the U-Matrix.
Shooting Phase
Shooting Phase
Shooting Phase
Shooting Phase
Dynamical Systems analysis

• Advantages of 3-D analysis

1. Depict the complete spatial motion of the players.

2. The trajectories of attacker – defender dyad or attacker-ball-defender triad can be visualized from above.

3. Reconstruction of performance through simulation.
Dynamical Systems analysis

• Advantages ANN to make 3-D analysis

1. MLP allows non-linear analysis.
2. Erroneous intrinsic & extrinsic camera parameters unaccounted.
3. VGA camera can be used instead of HD.
4. Camera orientation and position is not much of significance.
Dynamical Systems analysis

3-D reconstruction of stereo-vision using neural networks

\[ C_h = A W_h, \]

\[
\begin{bmatrix}
C_{h1} \\
C_{h2} \\
C_{h3} \\
C_{h4}
\end{bmatrix} =
\begin{bmatrix}
a_{11} & a_{12} & a_{13} & a_{14} \\
a_{21} & a_{22} & a_{23} & a_{24} \\
a_{31} & a_{32} & a_{33} & a_{34} \\
a_{41} & a_{42} & a_{43} & a_{44}
\end{bmatrix}
\begin{bmatrix}
X \\
Y \\
Z \\
1
\end{bmatrix}.
\]

Dynamical Systems analysis

Feed-forward neural net topology is to produce a non-linear mapping between the input and output neurons

Dynamical Systems analysis

Reconstruction of the trajectories in a 3-D space
Future Research

• Study the dyadic system between an attacker and a defender.

• Synergetic of a triad or small group.

• Study the chaotic attractors in a team sport.

• Analyze the perturbation changes.

• Other models like – Neural Gas & DyCoN
Conclusion

Thus ANN is an important tool for analyzing human movement individually and as a team.

Better tracking system and efficient lifelong learning models will make better qualitative analysis.
Thank You