

# Motion Analysis via Topological Tools

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# Data Size

Currently, the motion capture industry predominantly uses variations of "marker" methods, where each position (including rotation points) of joints or other essential body locations are recorded using sensors and translated into computational data

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# Data Size

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Currently, the motion capture industry predominantly uses variations of "marker" methods, where each position (including rotation points) of joints or other essential body locations are recorded using sensors and translated into computational data.

While straightforward, these methods limit motion capture to the confines of well-funded businesses.

# Increasing Demands

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# Increasing Demands

Effective in revealing flaws or weaknesses in a player's or a dancer's technique.

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# Increasing Demands

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Effective in revealing flaws or weaknesses in a player's or a dancer's technique.

Performance arts: gives a scientific evaluation of what makes certain movements **aesthetically appealing**.

# Network Topology

Consider the subject of motion capture as graph  
We can define the graph as follows:

## Definition

$G = (V; E)$  where  $V$  stands for vertices and  $E$  stands for edges.

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1  $V$  (vertices):  $\{v_1; v_2; v_3; v_4; v_5\}$

2  $E$  (edges):  $\{(v_1; v_3); (v_1; v_4); (v_2; v_4); (v_3; v_4)\}$

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In this case, we can express these sets as the following matrix

$$V = \{v_1; v_2; v_3; v_4; v_5\}, E = \{(v_1; v_3); (v_1; v_4); (v_2; v_4); (v_3; v_4)\}$$

With the given matrix, we can then further compress the data by defining the topology of the given graph  $G; E$ .

# Grouping Movements

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Certain movements can be compacted under the network topology of a singular structure.

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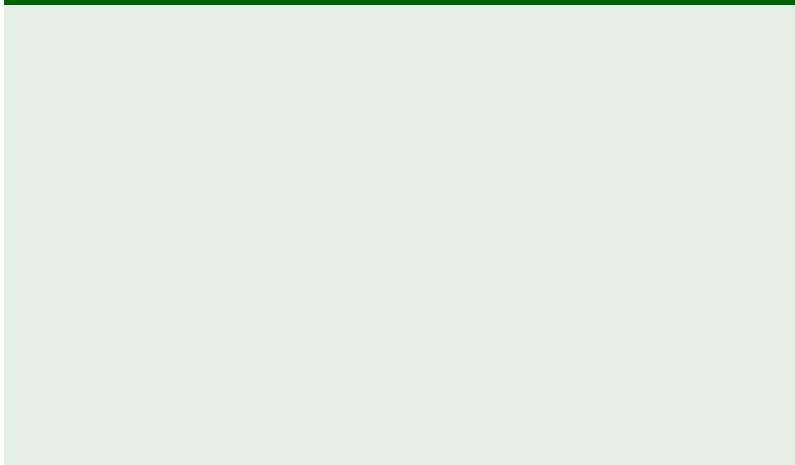
Certain movements can be compacted under the network topology of a singular structure.

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# Grouping Movements

Note that not all movements share the same network topology

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# Topological Manifolds: Adding rotations

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In a general sense, **topological manifold** is a topological space that locally resembles a real  $n$ -dimensional Euclidean space.

For any point in the space, there exists an open set containing the point, and we can create a smooth map (infinitely differentiable and invertible) between the open set of the given topological manifold and some open set of the Euclidean space.

# The Orthogonal Group

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The definition of an **orthogonal group** is given as follows:

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The definition of an **orthogonal group** is given as follows:

Definition

$$O(n) = \{R \in M_{n \times n} : R^T = -R\},$$

where  $M_{n \times n}$  is a set of real valued matrices of size  $n$ .

# The Orthogonal Group

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The definition of an **orthogonal group** is given as follows:

## Definition

$$O(n) = \{ R \in M_{n \times n} : R R^T = I_n \},$$

where  $M_{n \times n}$  is a set of real valued matrices of size  $n$ .

Then, assuming that one of the two body parts is fixed in position, we can say that the other body part's position can be corresponded to an element  $O(3)$ .

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# Summary

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## 1 Network Topology :

Considers the human body as a graph. Instead of plotting specific points all around, we simply connect two vertices with a vector line.

## 2 Topological Manifolds :

Investigates the states of joints as an element of  $\mathbb{R}^3$  to express the human body.

(More research needed: calculating the rotations required more data than given by the 20th century video file (torsion, for example).)



Click the link to access the full paper:  
<https://tinyurl.com/2hejdzzc>

THANK YOU!

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