BIPARTITE NETWORK for ACTION - MUSCLE MAPPING

Dhawal Kabra | Lokesh Khandelwal | Manav Parmar

Project presentation as part of ES404 | Networks and Complex Systems

Supervised by **Prof. Udit Bhatia**

MyoMapper

MOTIVATION

Humans play more than 8000 sports, of which 200 are internationally recognised. Yet, a very common notion is that athletic people are good at all of them. After all, all actions are simply a sequence of activations of muscles from the same body. But in reality, how similar are two different sports, like swimming and cricket, and which are the few key muscles that make a true athlete? By understanding how different sports utilise similar muscle groups, individuals can improve performance, enhance enjoyment, and minimise injury risks. This knowledge can help them strengthen key muscles, optimise cross-training benefits, and choose sports that complement their natural proficiencies.

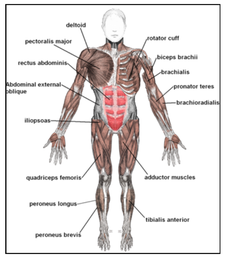

FIGURE 1 ***Anterior Muscles in Human Body***

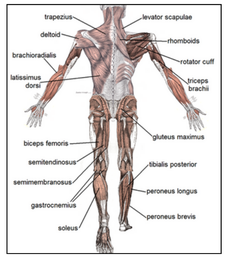

FIGURE 2 ***Posterior Muscles in Human Body***

DATA COLLECTION

The bipartite network has two different nodes: actions and muscles. Humans have around 260 skeletal muscles, and data was collected based on actions performed by each muscle group. Unfortunately, most actions collected this way are extremely low-level, with no real discernable pattern among themselves or their corresponding muscle groups.

To counter this, we reversed our approach. We made a list of some of the most played sports worldwide. Some of the most frequent actions in each sport were selected using open-source polling sites. Then, each action was linked to the muscles involved in performing it. In most cases, there is no one way to perform these actions correctly. So, once again, the data available on open-source sports science blogs and websites was used to counter regional or other biases.

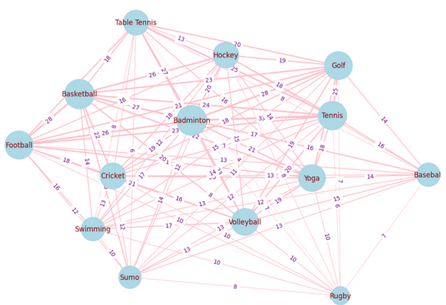

FIGURE 3 ***The current network has around 107 muscle nodes used to perform 201 different actions across 14 sports.***

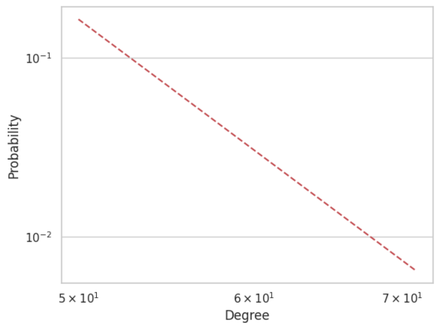

FIGURE 5 ***Power law fit for degree distribution of Muscle Network***

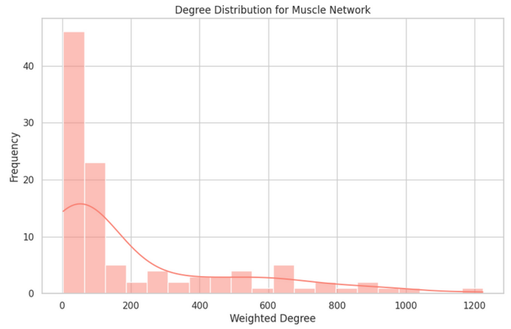

FIGURE 6 ***Degree Distribution for Muscle Network***

EXPERIMENTS AND INFERENCES

ACTION NETWORK IS SMALL WORLD!

It is observed that the action network has a network diameter of 3 and an average path length of 1.32; these point towards a small world. The largest connected component contains all the nodes, and most nodes have a considerable weighted degree. This suggests that most actions are already connected to most others and can be learnt with some effort.
Further analysis shows that mastering any one sport does not necessarily mean mastery of all others. It may give a leg up in one or two other sports, but the actions have enough variety (robustness) to keep one challenged. A better bet would be to practice specific steps from different sports, for example, sun salutation pose, butterfly stroke and football dribbling, to build a foundation for focusing on any specific sport later.

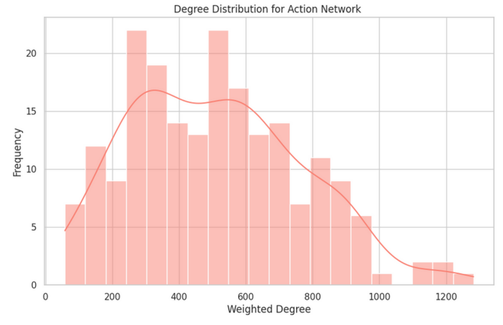

FIGURE 4 ***Degree Distribution for Activity Network***

MUSCLE NETWORK IS SCALE-FREE!

The muscle network has most nodes with very low degrees and a few with extremely high degrees (hubs) with a power law degree distribution, highlighting its scale-free nature. It is susceptible to targeted attacks, so its robustness can be improved by focusing on the hubs.
This means simply focusing on these key muscles (hubs) can help improve an athlete's resilience to injuries and overall performance. These include triceps brachii, pectoralis major, hamstrings, gluteus maximus, deltoids lateral and others. Sports science can focus its resources on figuring out strengthening and recovery techniques for these muscles. This also hints towards the presence of so-called "natural athletes".
Another analysis showed that Yoga uses the maximum variety of muscles as a sport. However, as the previous analysis showed, not all muscles are equally important. Badminton is the sport with the highest weighted connections to these so-called hubs, followed by Tennis. A budding athlete would develop stronger hub muscles playing these, though a focused custom training regime is still the best choice.

YOGA AND BADMINTON: **WAY TO SPORT DOMINATION**

Sports	Top Connection
Badminton	Tennis
Cricket	Yoga
Football	Basketball
Basketball	Football
Rugby	Cricket
Tennis	Badminton
Baseball	Yoga
Hockey	Yoga
Swimming	Badminton
Volleyball	Badminton
Golf	Badminton
Sumo	Yoga
Table Tennis	Badminton
Yoga	Basketball

We developed a similarity function between sports based on the weighted connections of muscles involved in performing their respective actions.

Movement	Related Movements
Cricket Pull shot	Cricket Cut shot, yoga triangle pose
Table tennis forehand smash	volleyball jump serve, badminton smash
Basketball shooting free throw	volleyball jump serve, volleyball attack (spike)
Tennis slice	tennis backhand slice, yoga downward facing dog
Badminton drop shot	table tennis forehand drive, badminton drive

Want to learn a new sport but don't know where to begin? A similar similarity function between actions can help figure out the best move to begin with.

FUTURE WORKS

Our dataset, while quite considerable, is far from exhaustive. Many sports, actions, and muscles still have yet to be explored, but collecting accurate data is a big roadblock. To solve this, we created a website allowing interested parties to contribute data directly to this project. The website will have the current network plots and dataset for others interested. Also, we plan a chatbot on the website, allowing visitors to interact with the data and draw their own analysis and insights.

A major drawback of our analysis is that not all actions within a sport are performed with the same frequency. While the frequency of actions is highly subjective from player to player and across time, if the data can be collected, we could use central measures to get a more robust analysis. Also, comparing the action and muscle networks of different players or eras across sports could lead to interesting insights.

References: 1. "Skeletal Muscle - Wikipedia." En.m.wikipedia.org, en.m.wikipedia.org/wiki/Skeletal_muscle" 2. "Playo." Playo, blog.playo.co/amp/"