Motion Browser: Visualizing and Understanding Complex Upper Limb Movement Under Obstetrical Brachial Plexus Injuries

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Childbirth "Arm Nerves"

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Agenda

Introduction

Tasks and Design

Case Study

Conclusion

Introduction

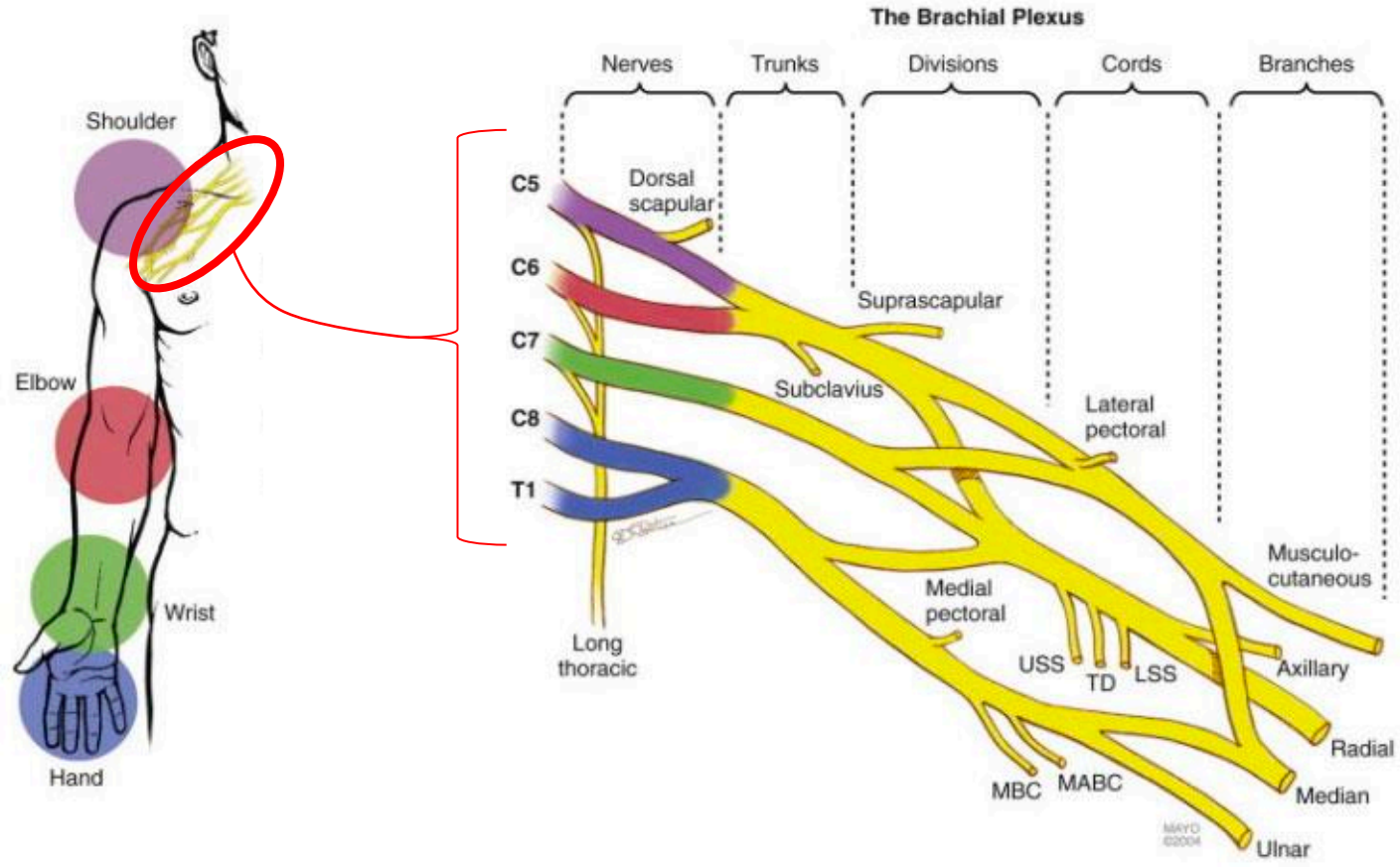
Introduction

Obstetrical Brachial Plexus Injuries

An injury to the nerves that control the muscles on the upper limb around the time of birth.

The brain will conduct some compensatory actions when some of the muscles cannot be used.

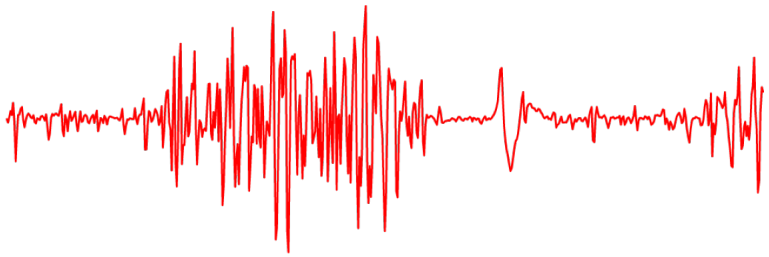
How does our brain coordinate the muscles under the injury are still not well studied.

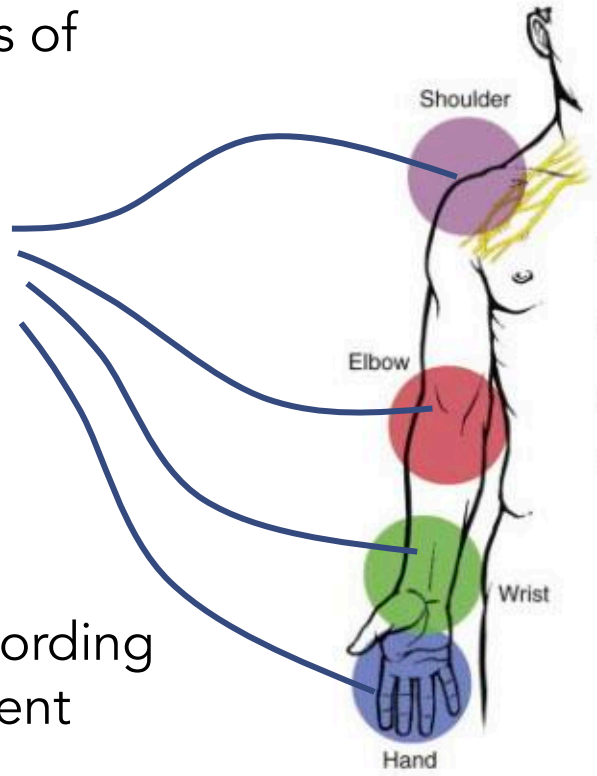


Introduction

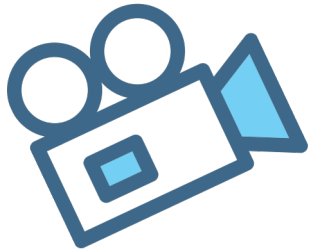
Active Range Of Motion Assessment

1 Electromyography (EMG) signals of muscle activations





2 Motion sensors recording limb displacement



3 Video recordings

Introduction

Active Range Of Motion Assessment

Active Range of Motion (AROM) dataset:

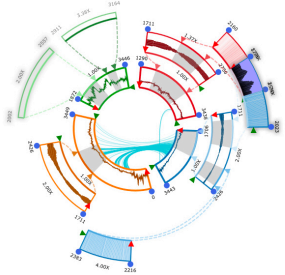
1. 8 patients in total (each with one injured limb)
2. 8 muscle sensors on each limb for each patient
3. 3D motion tracking on each limb
4. Video recordings on each motion
5. 16 motions (shoulder, elbow and wrist) performed by each patient

Introduction

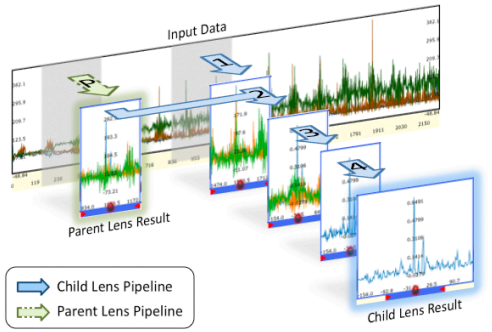
Challenges

Comparing affected and unaffected limbs among all patients

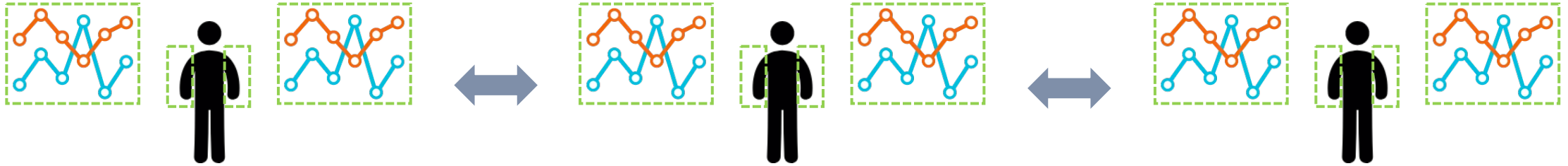
SignalLens TVCG 2010



Kronominer SIGCHI 2011



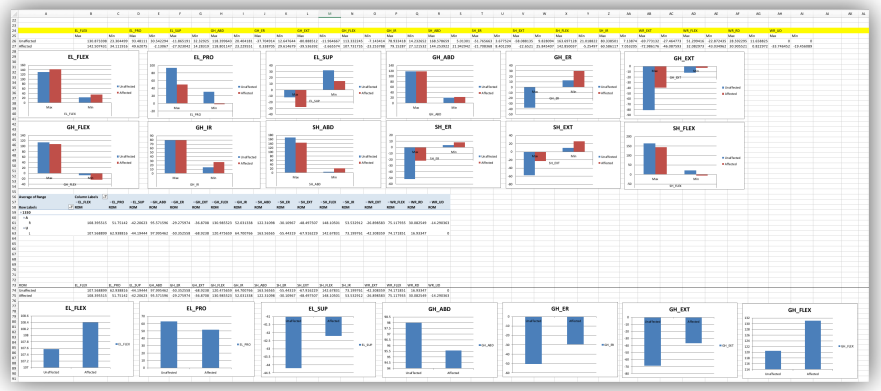
Chronolens TVCG 2011



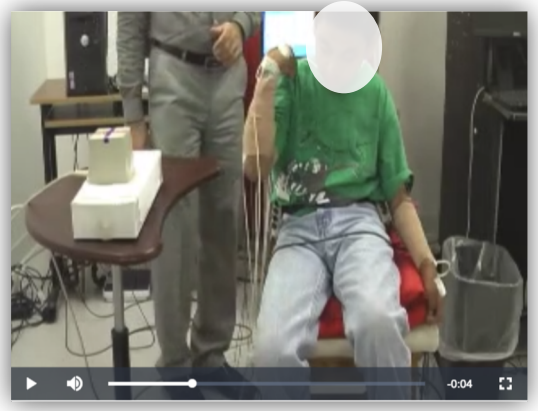
No effective techniques to visually compare multiple multivariate temporal muscle signals between different limbs.

Introduction

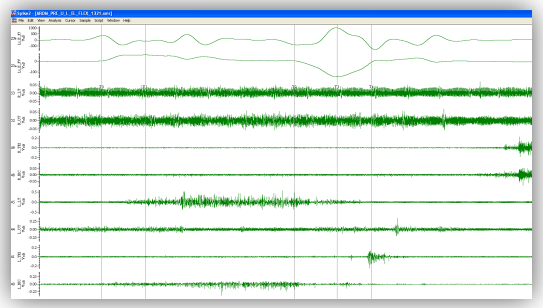
Challenges



Data Analysis



Videos

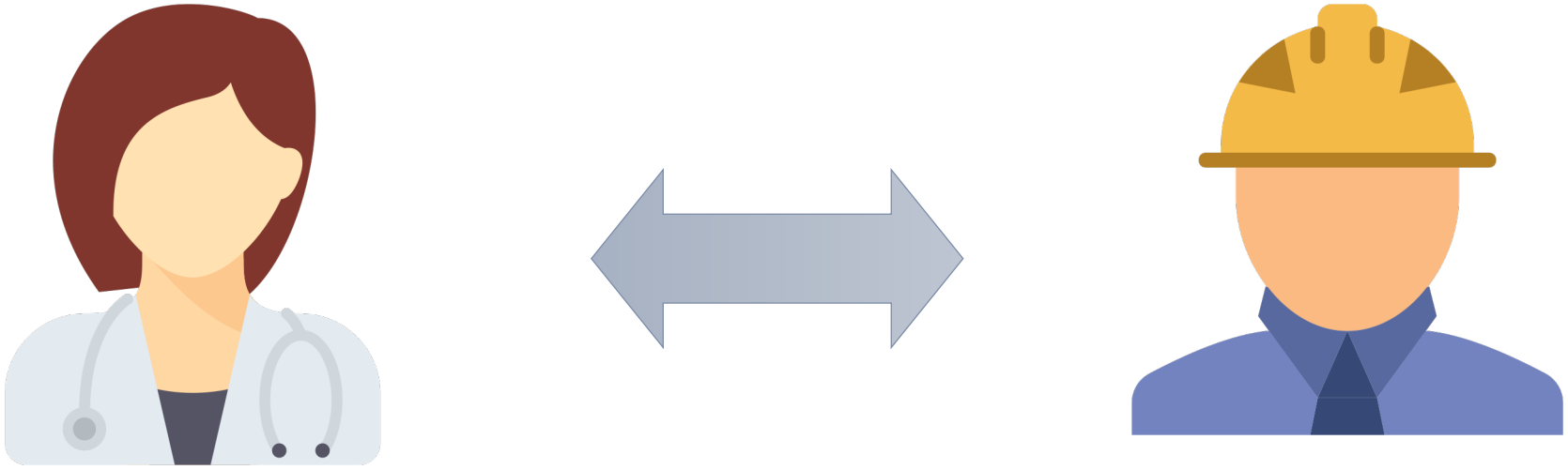


Motion and Muscle Signals

Integrated platform to inspect, compare and analyze the multimodal motion assessment data.

Task and Design

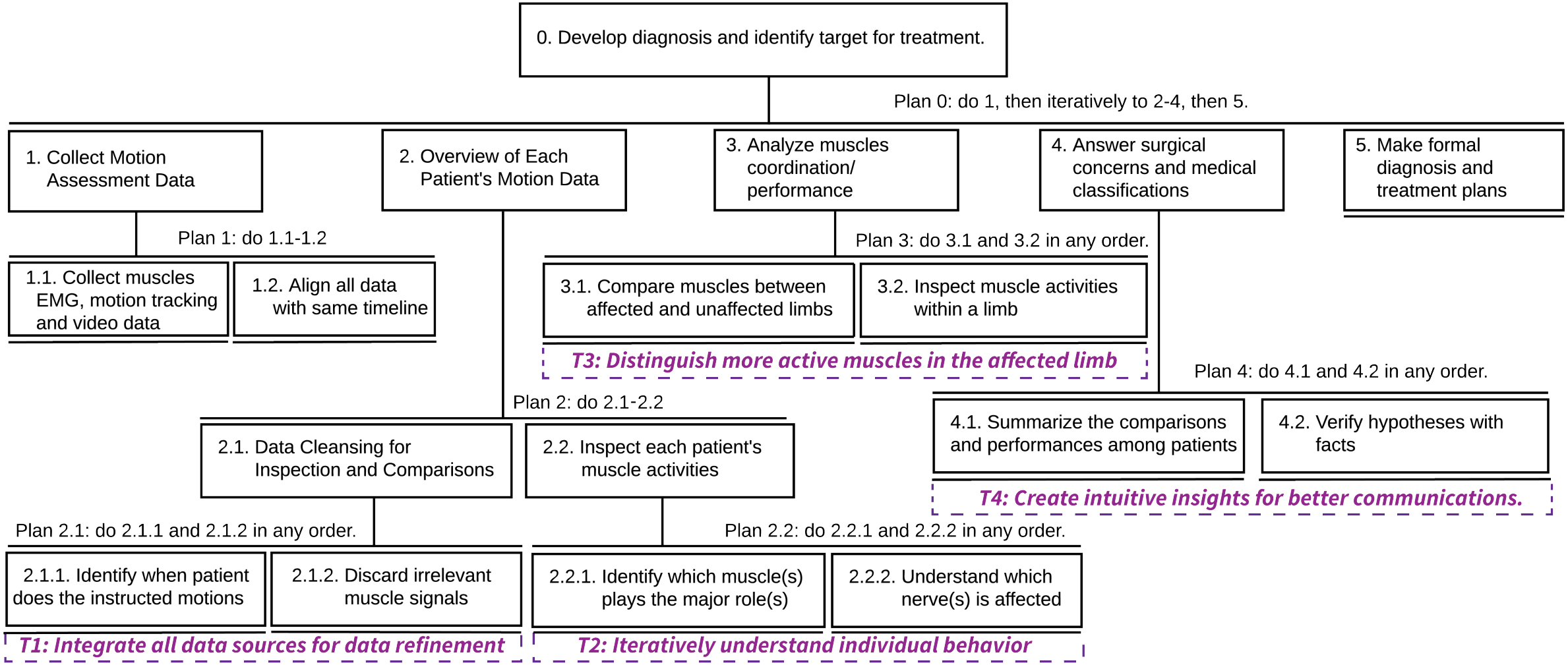
Task and Design
Task Abstraction



How to extract system requirements from professional medical workflow?

Task and Design

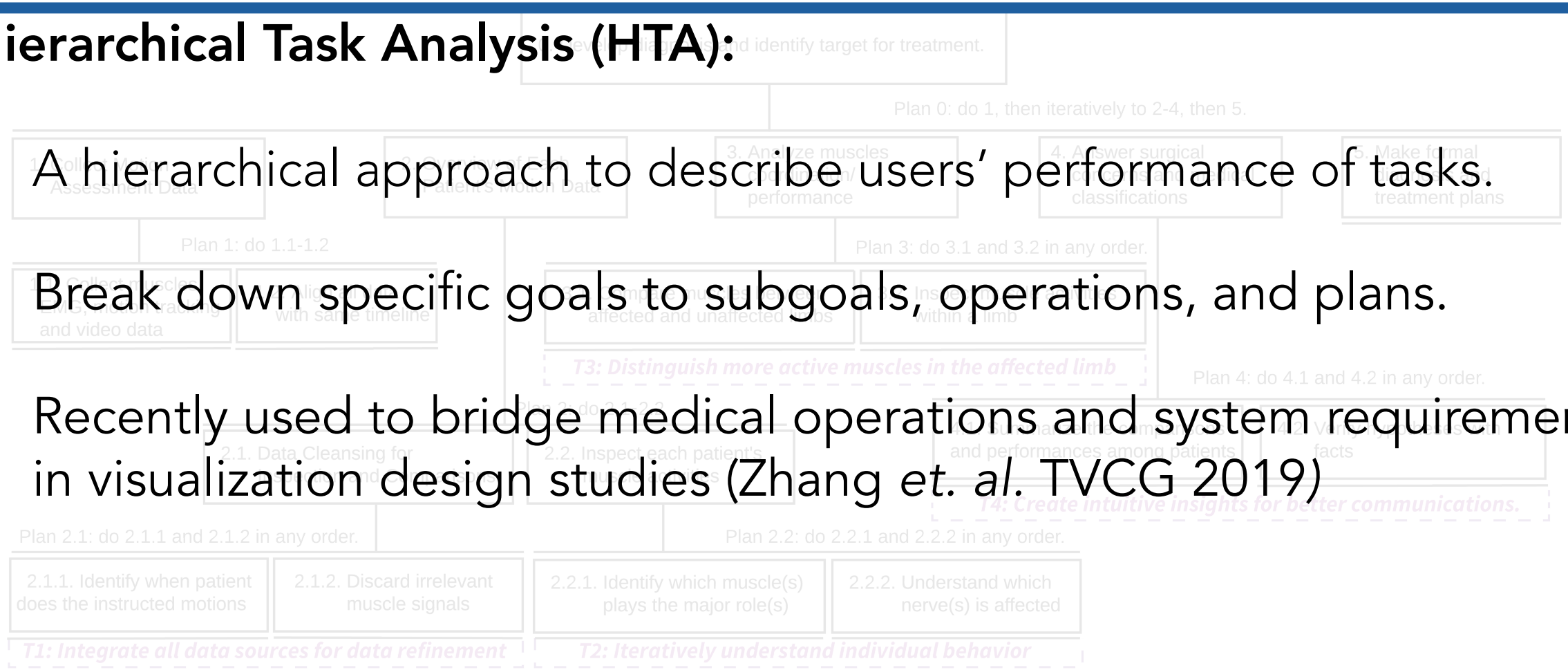
Task Abstraction



Task and Design
Task Abstraction

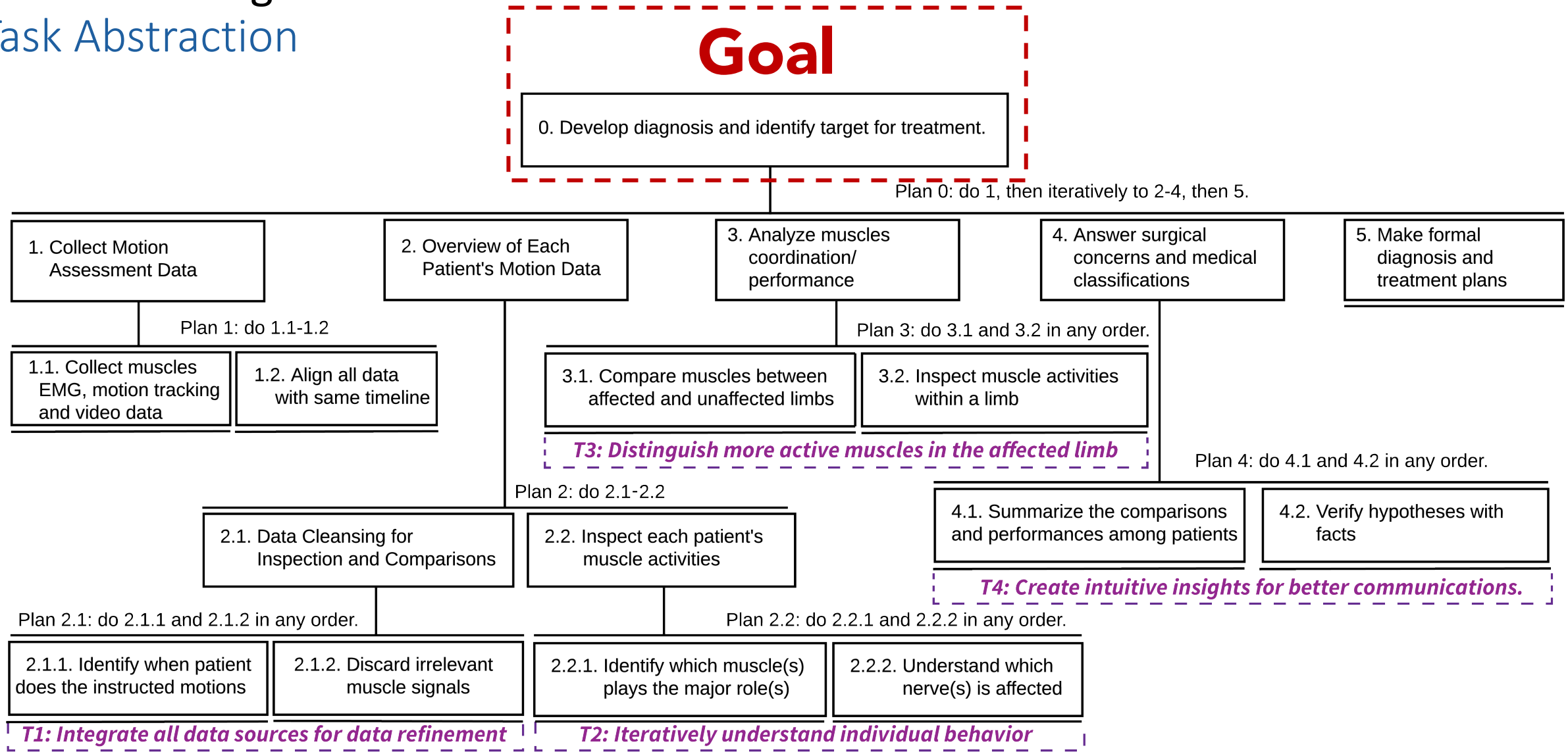
Hierarchical Task Analysis (HTA):

- A hierarchical approach to describe users' performance of tasks.
- Break down specific goals to subgoals, operations, and plans.
- Recently used to bridge medical operations and system requirements in visualization design studies (Zhang *et. al.* TVCG 2019)



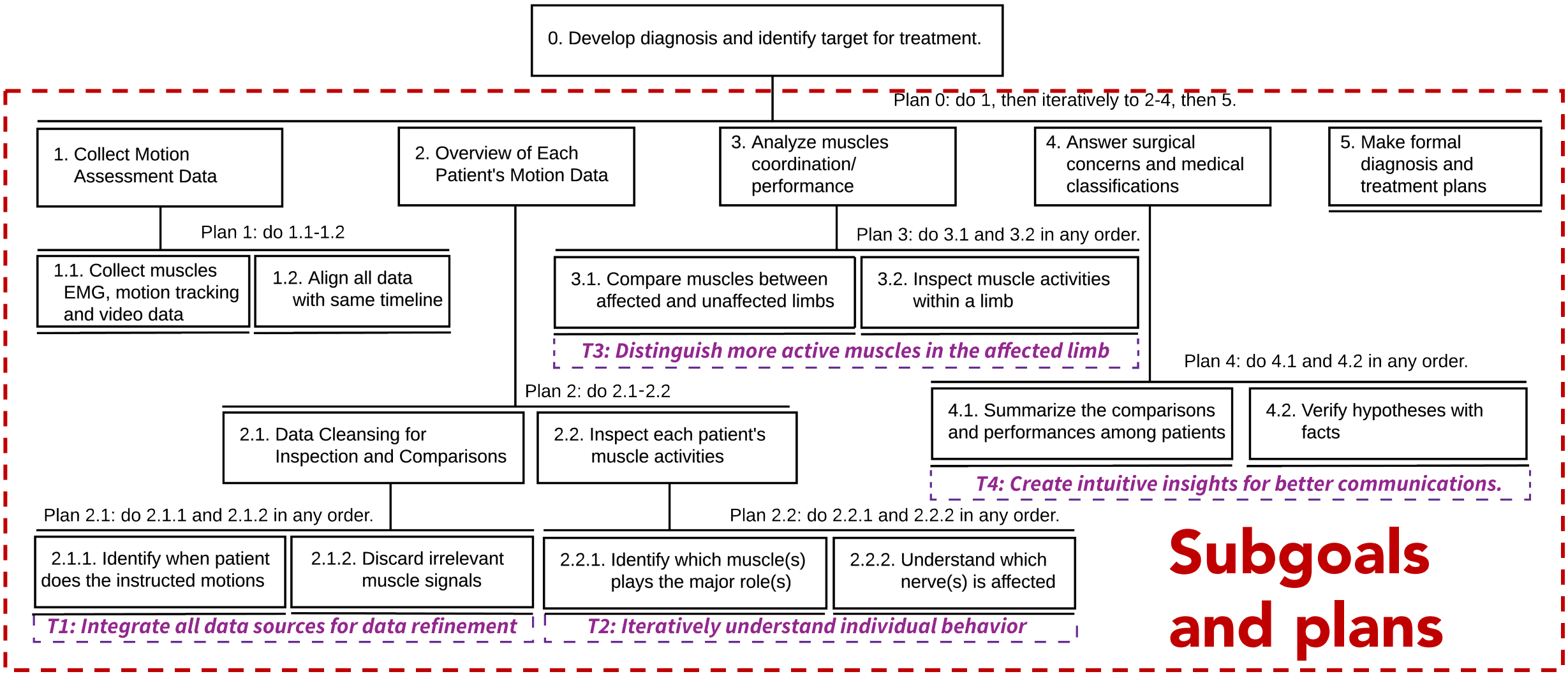
Task and Design

Task Abstraction



Task and Design

Task Abstraction



Task and Design

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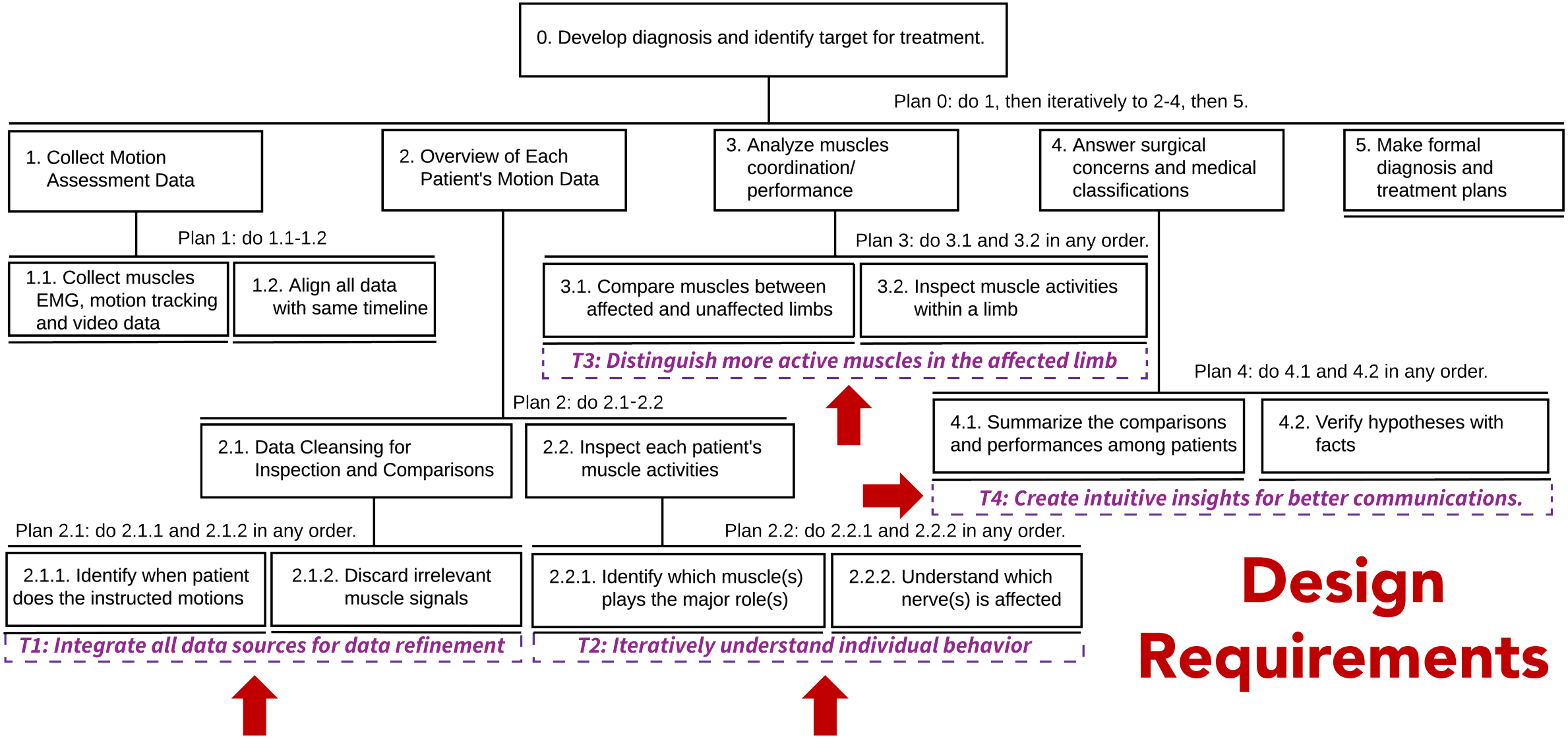


Design Requirements

Task and Design

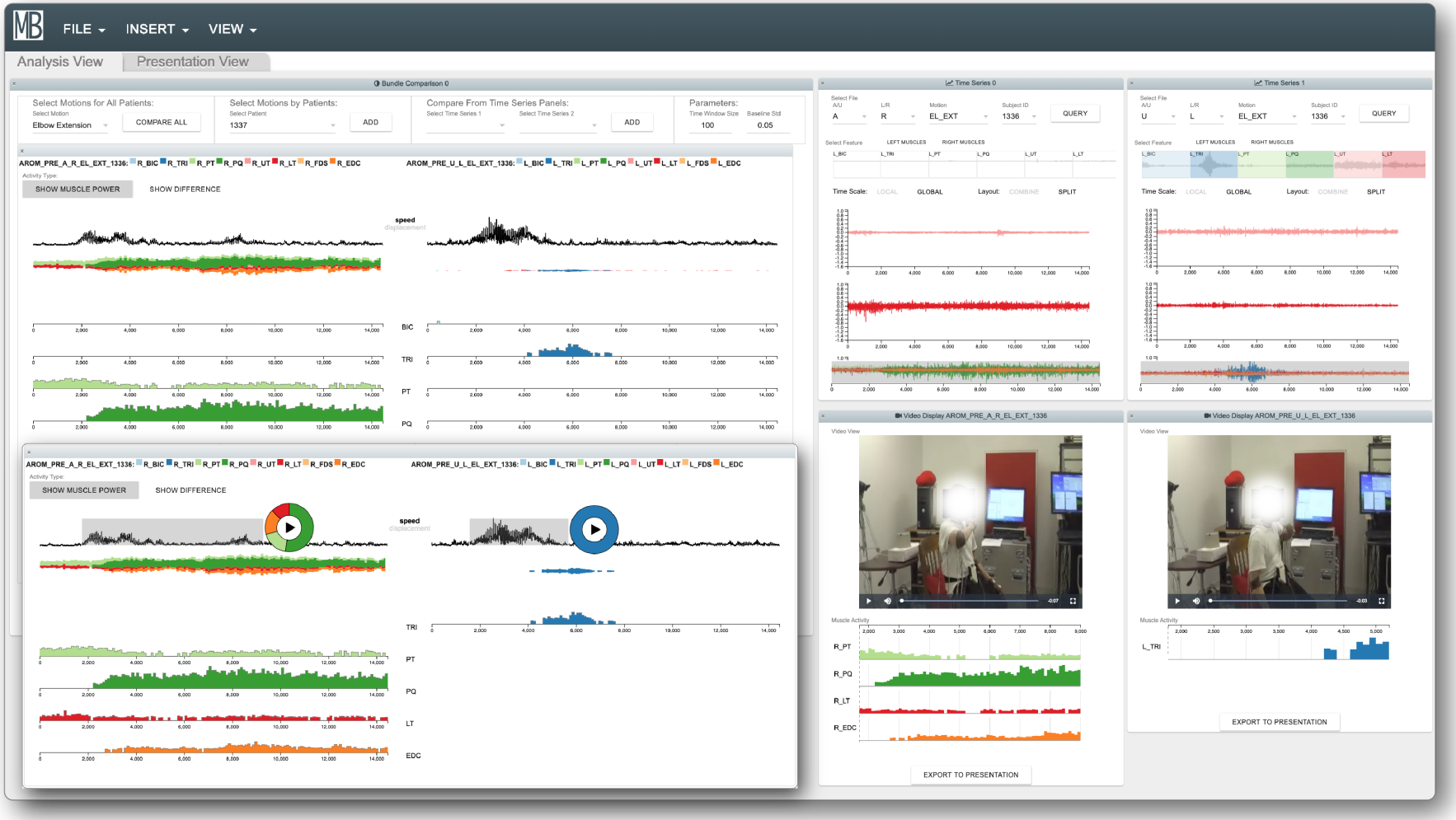
Task Abstraction

Design Requirements:

1. Align heterogeneous data sources temporally.
2. Display and analyze performance in one view for each patient.
3. Enable efficient comparative analysis.
4. Export the clinical analysis for presentation.

Task and Design

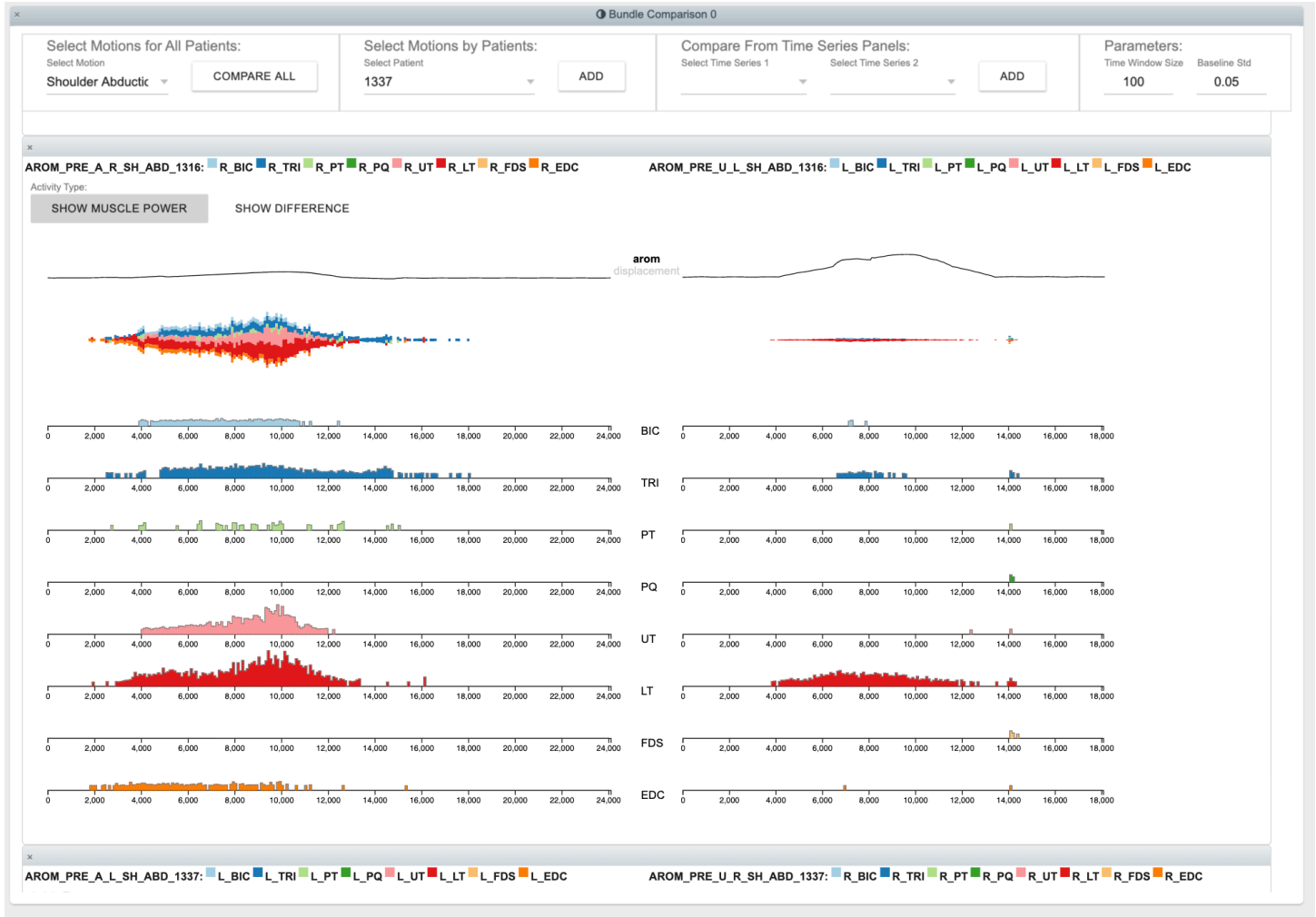
System Design



Task and Design

System Design

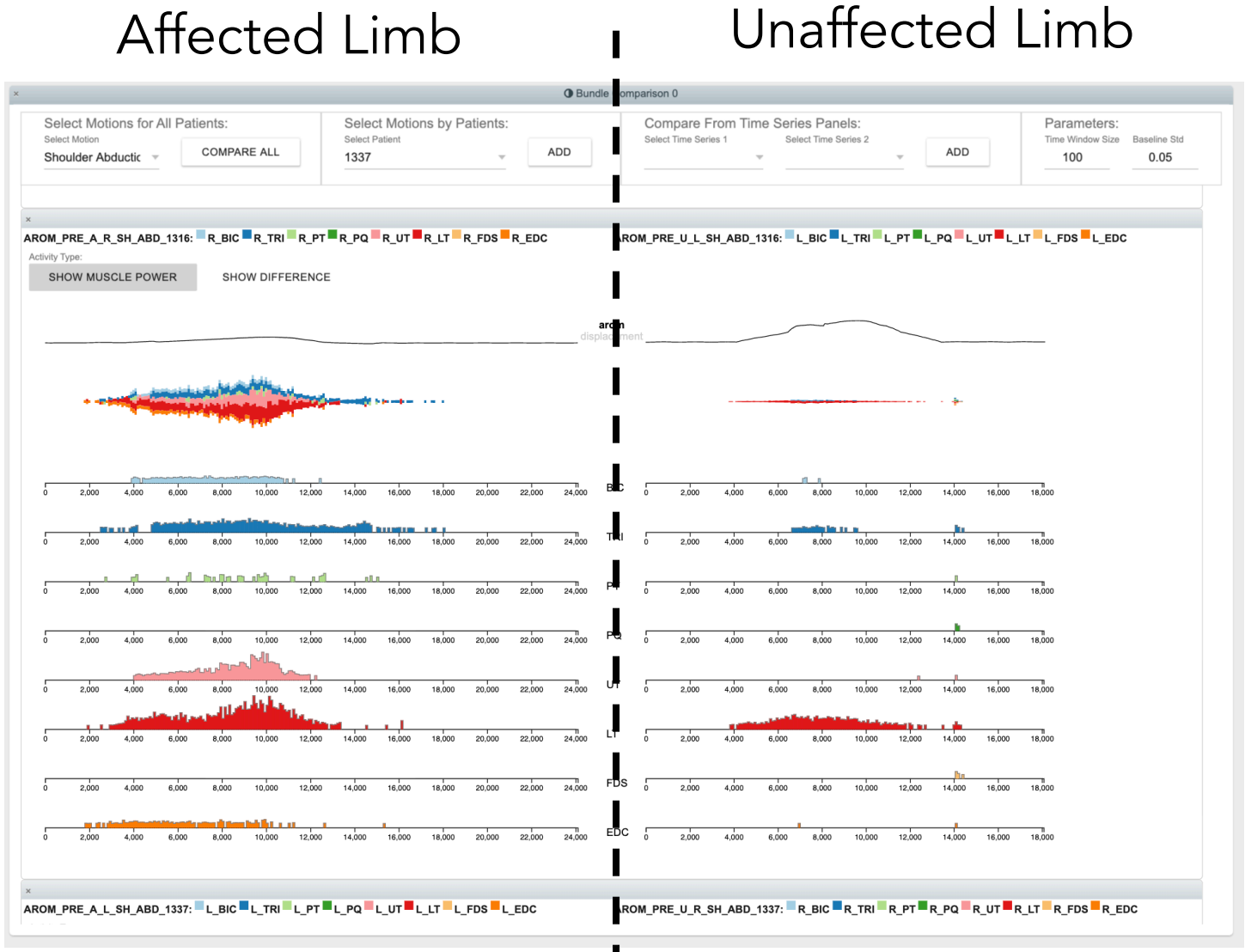
The system first loads the motion result for each patient in each window.



Task and Design

System Design

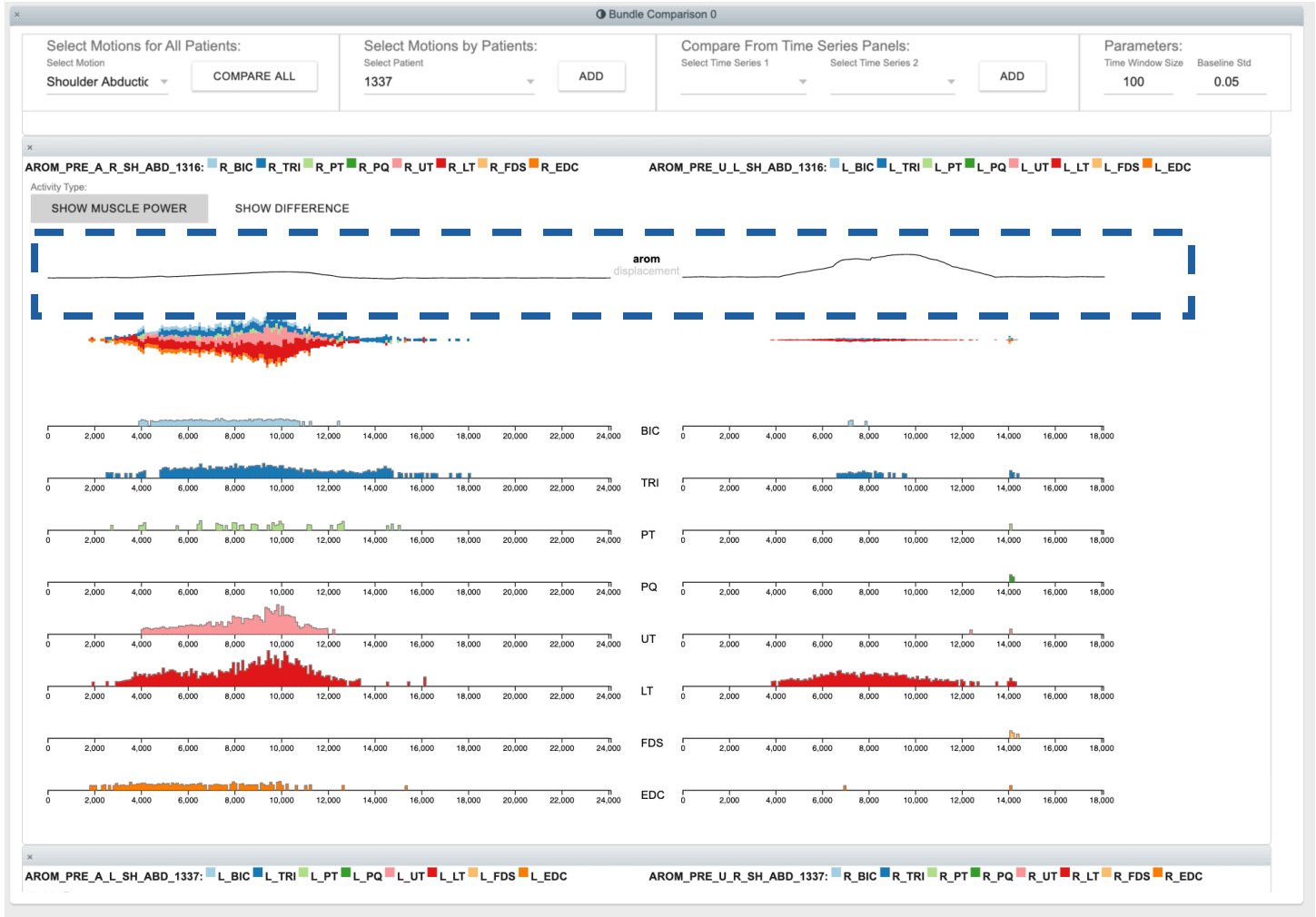
Motion results of the affected limb are placed on the left-hand side, while results of the unaffected limb are on the right-hand side.



Task and Design

System Design

Line chart shows the motion results (e.g. the displacement/ rotation of the limb)



Task and Design

System Design

Bar charts show the muscle activations.

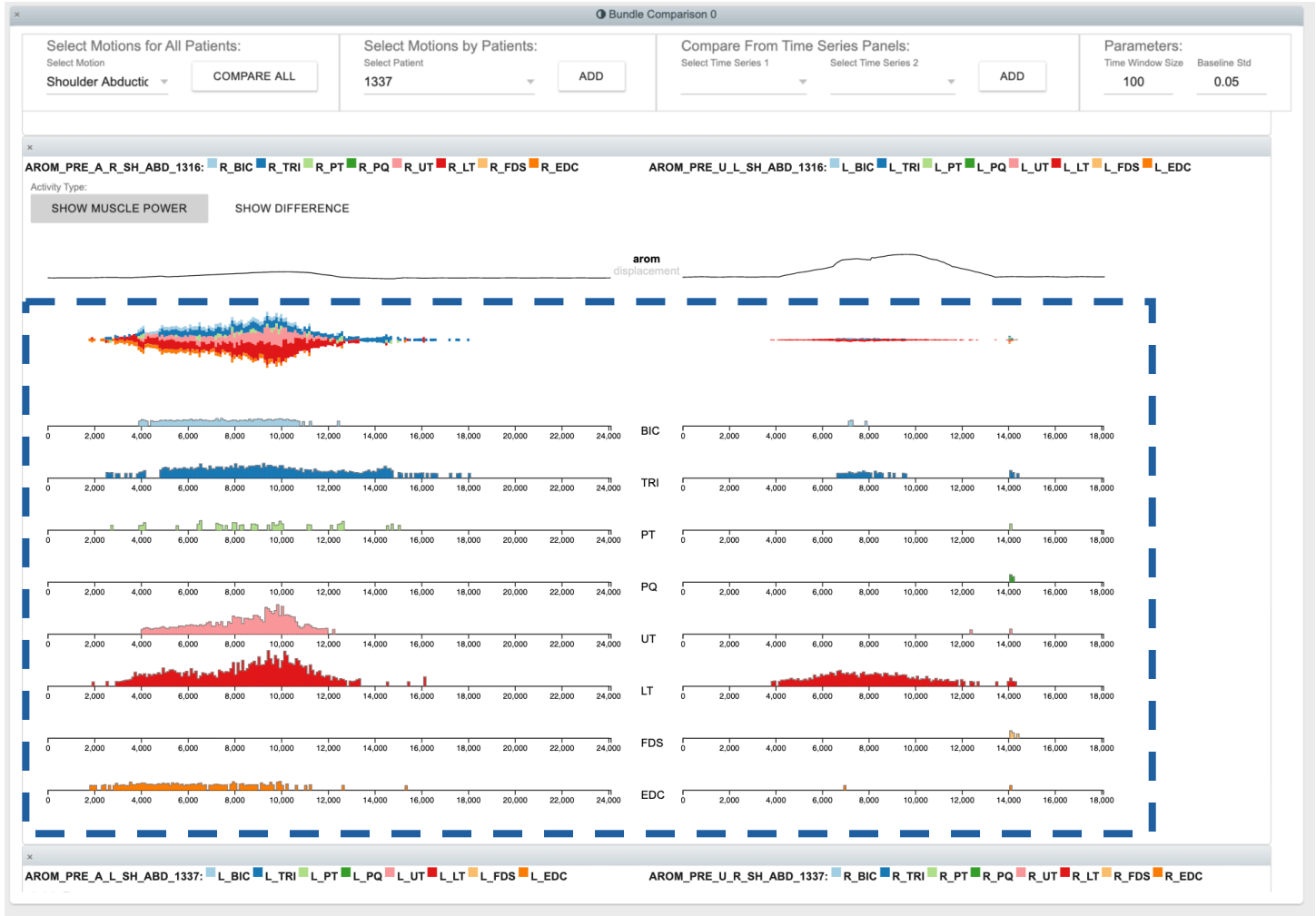
Same muscles from both limbs are encoded with the same color and vertical position.

BIC, TRI (Muscles from the upper arm)

PT, PQ (Muscles from the forearm)

UT, LT (Muscles from the back)

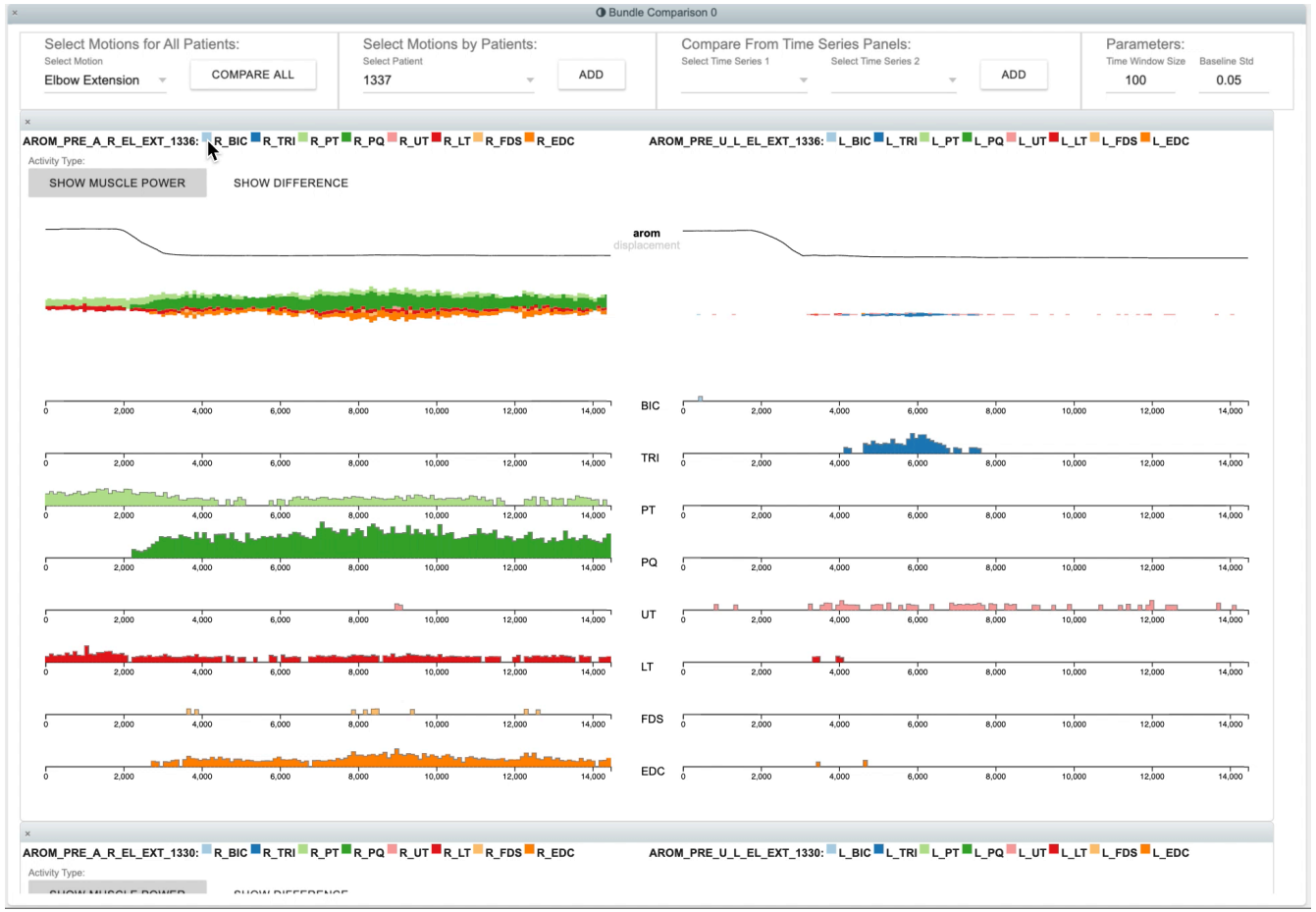
FDS, EDC (Muscles from the fingers)



Task and Design

System Design

Although placing patients in each view allows physicians to get a clear inspection of patients' data, comparing muscles one by one is a tedious task.



Task and Design

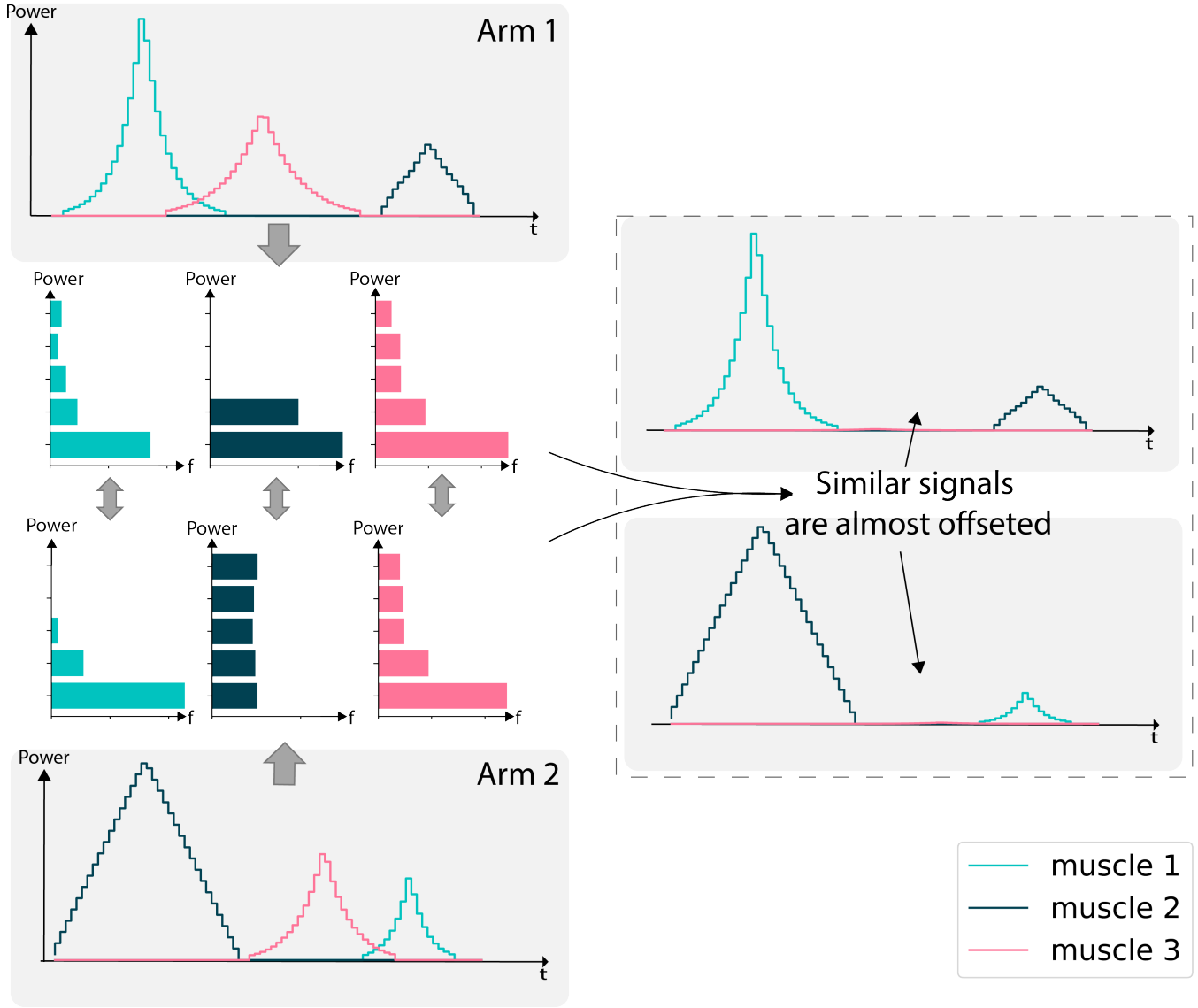
System Design

Remove similar muscle activities:

1. Transform the signals of each muscle into a histogram.

2. Compute the KL-divergence of the histograms between the limbs.

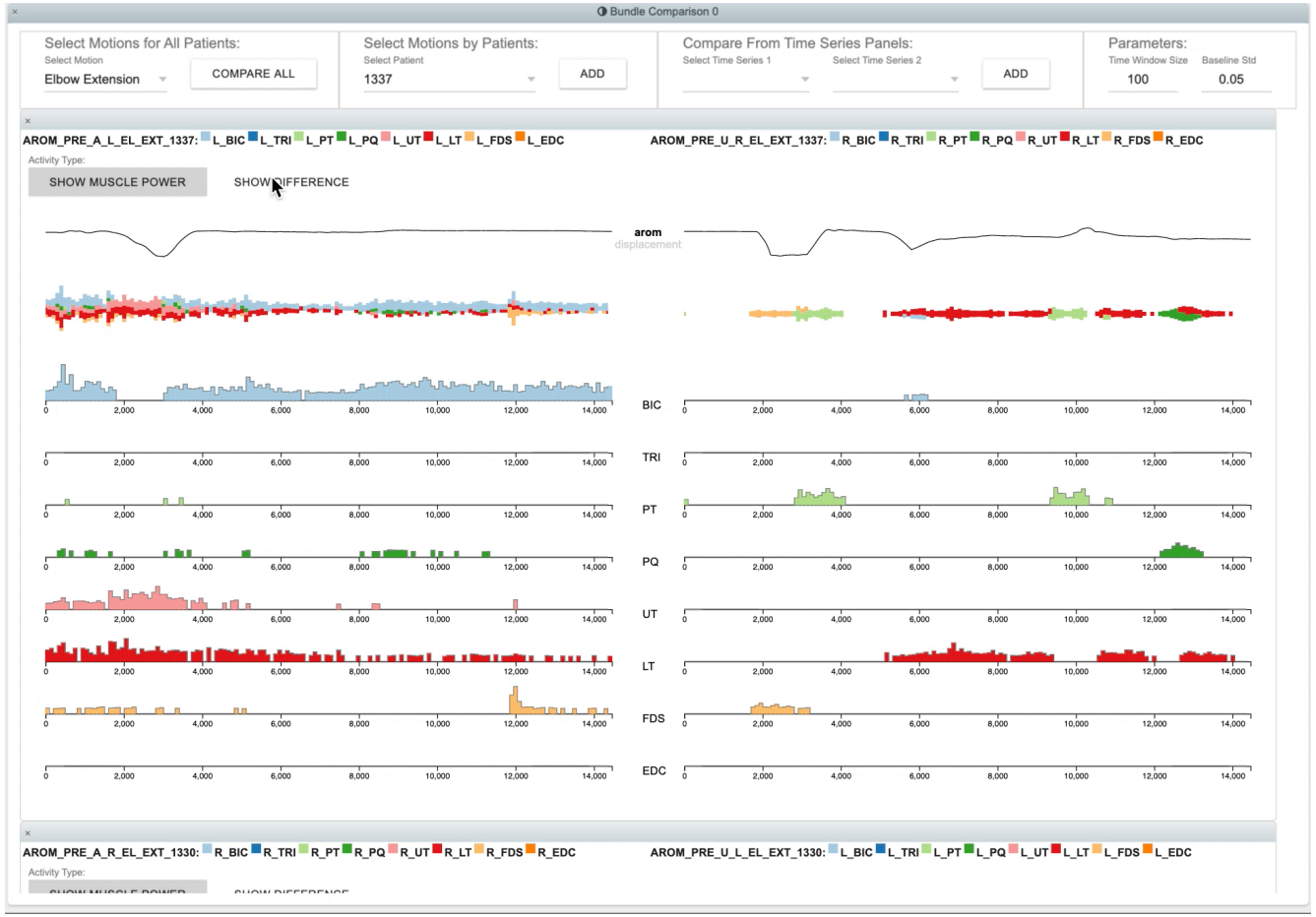
3. The lower the values of KL-divergence, the more similar the muscle activities are.



Task and Design

System Design

The technique allows analysis through filtering, speeding up the interactions per patient.



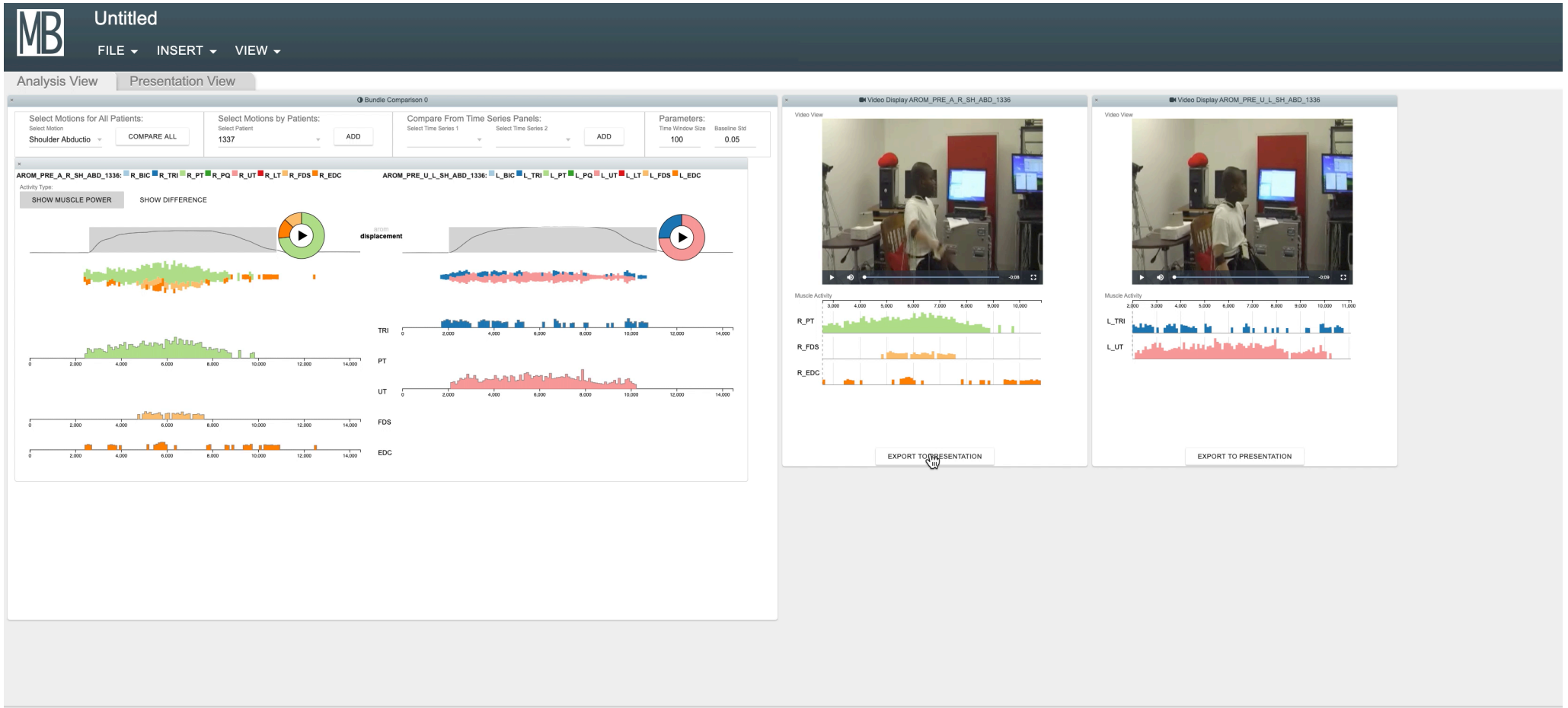
Task and Design

System Design

Extract video cutscenes

Task and Design

System Design

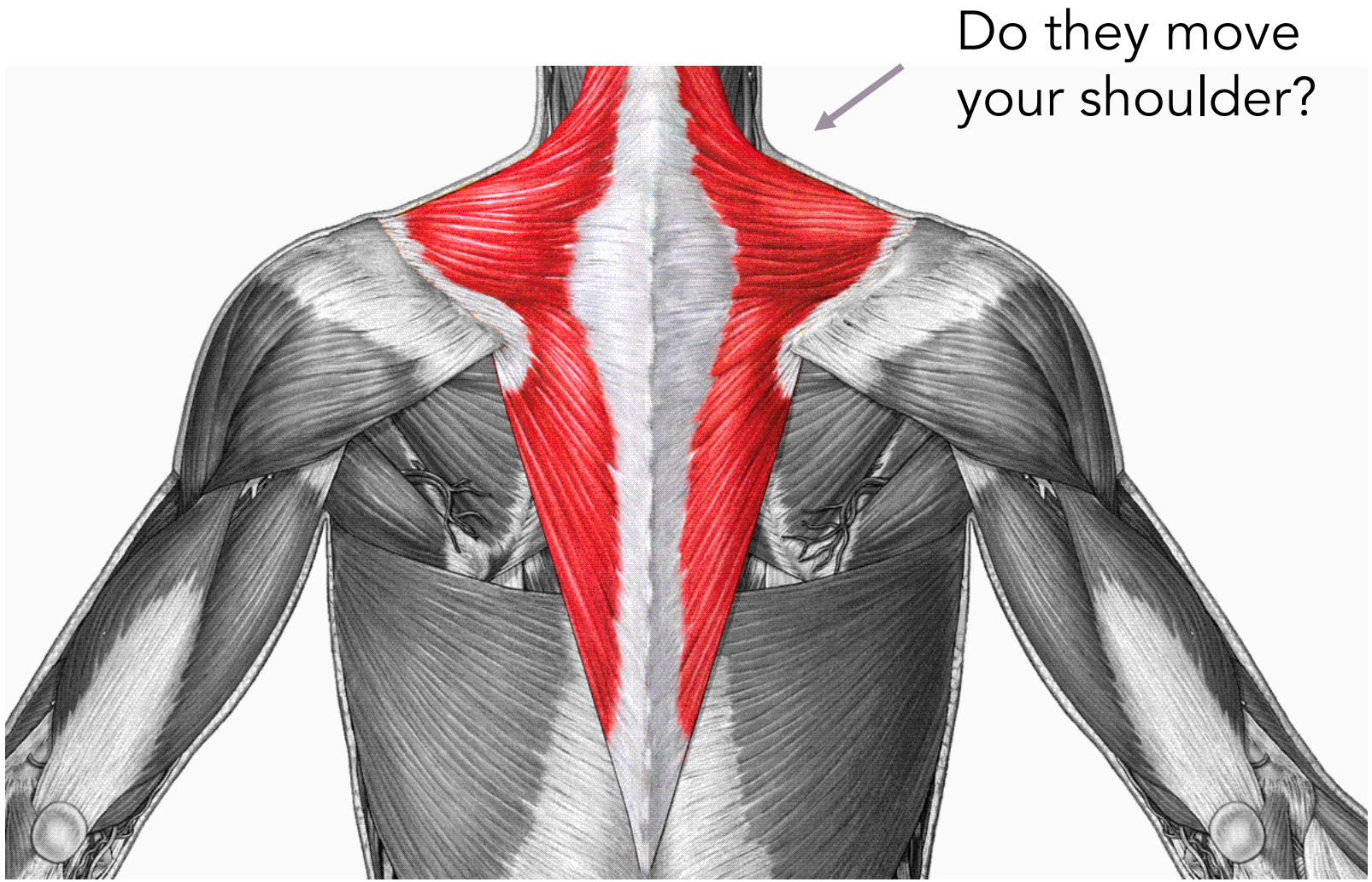


Presentation View

Case Study

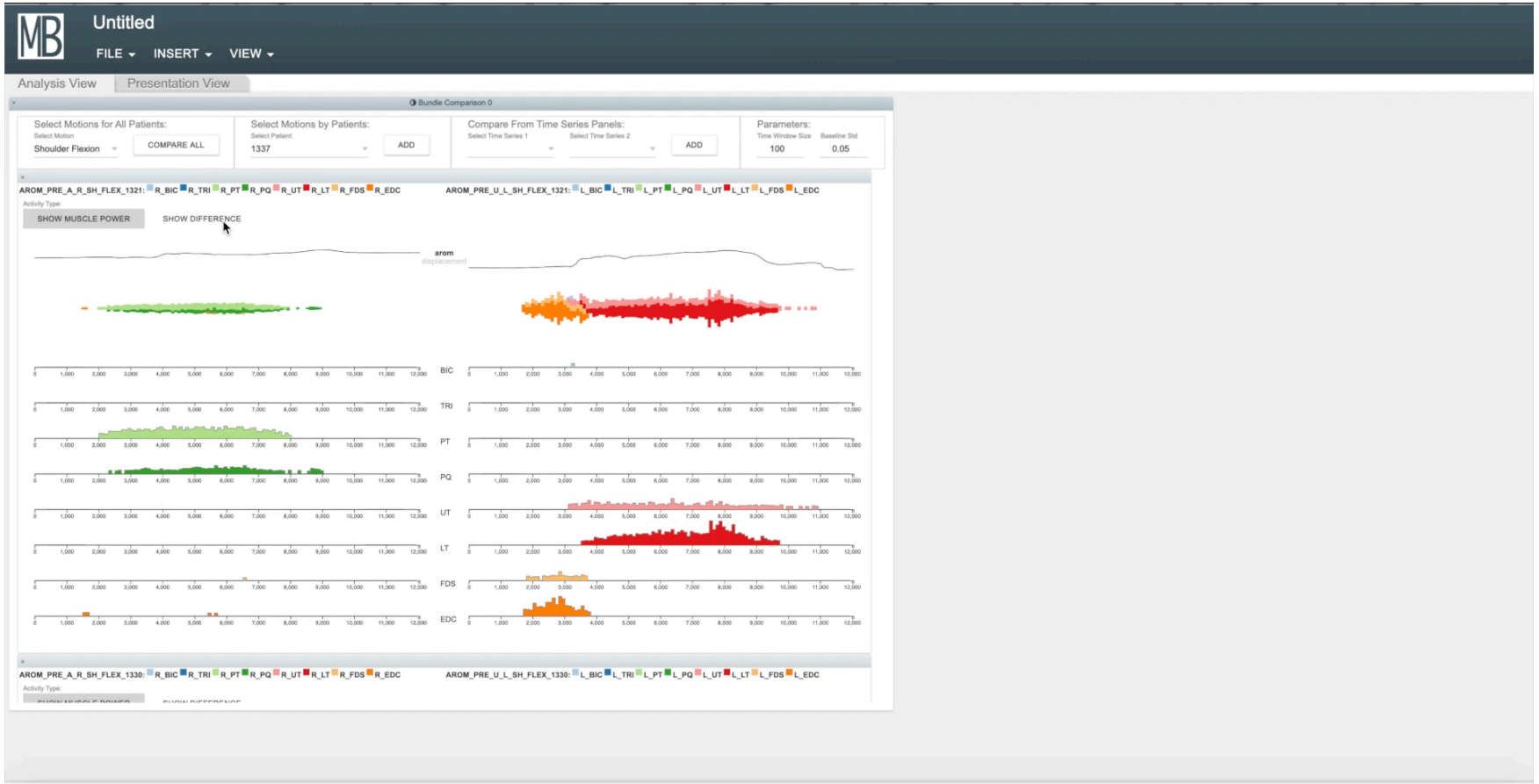
Case Study

Usefulness of Trapezius Muscles on Shoulder Motion



Case Study

Usefulness of Trapezius Muscles on Shoulder Motion

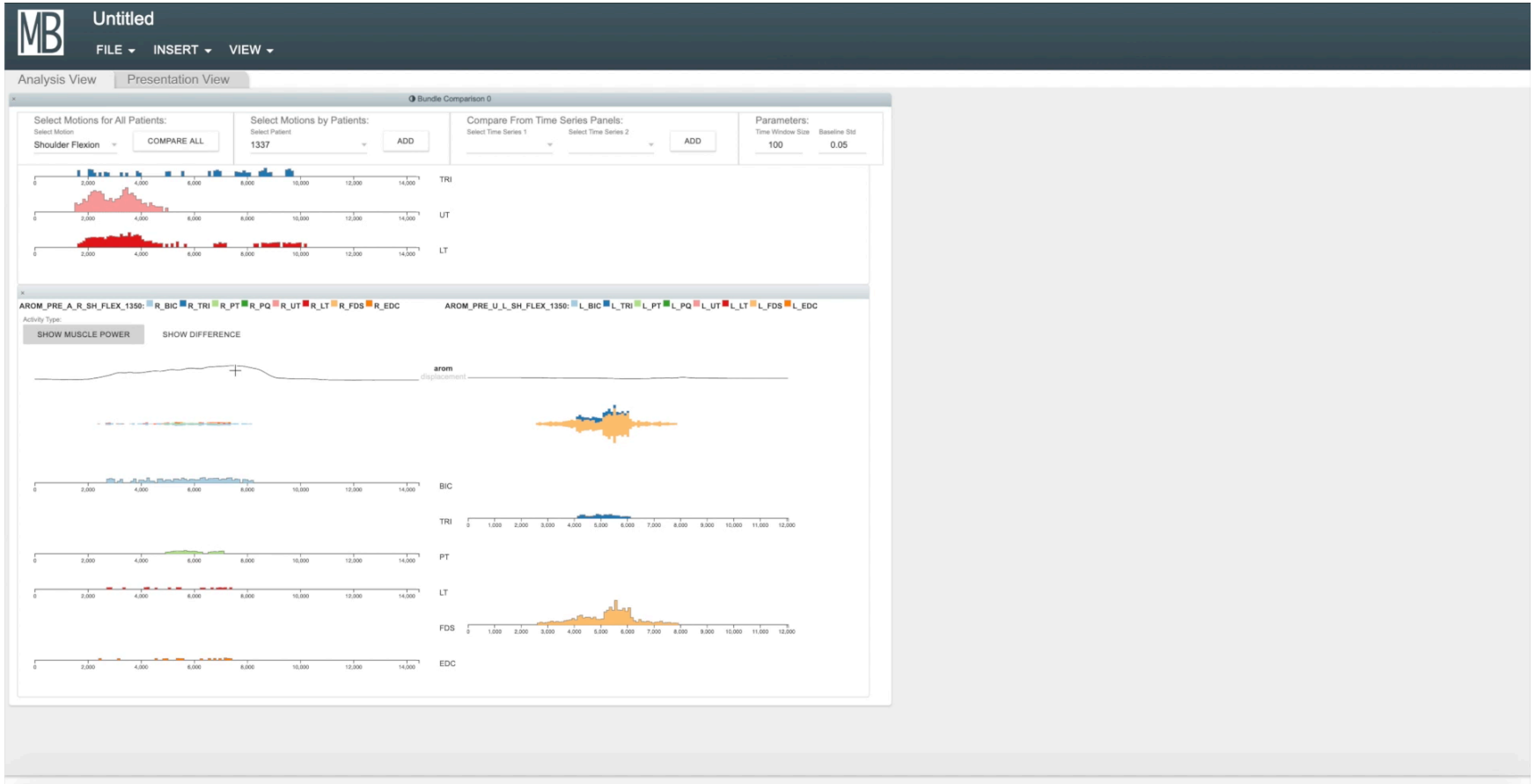


Upper Trapezius Muscles

Lower Trapezius Muscles

Case Study

Usefulness of Trapezius Muscles on Shoulder Motion

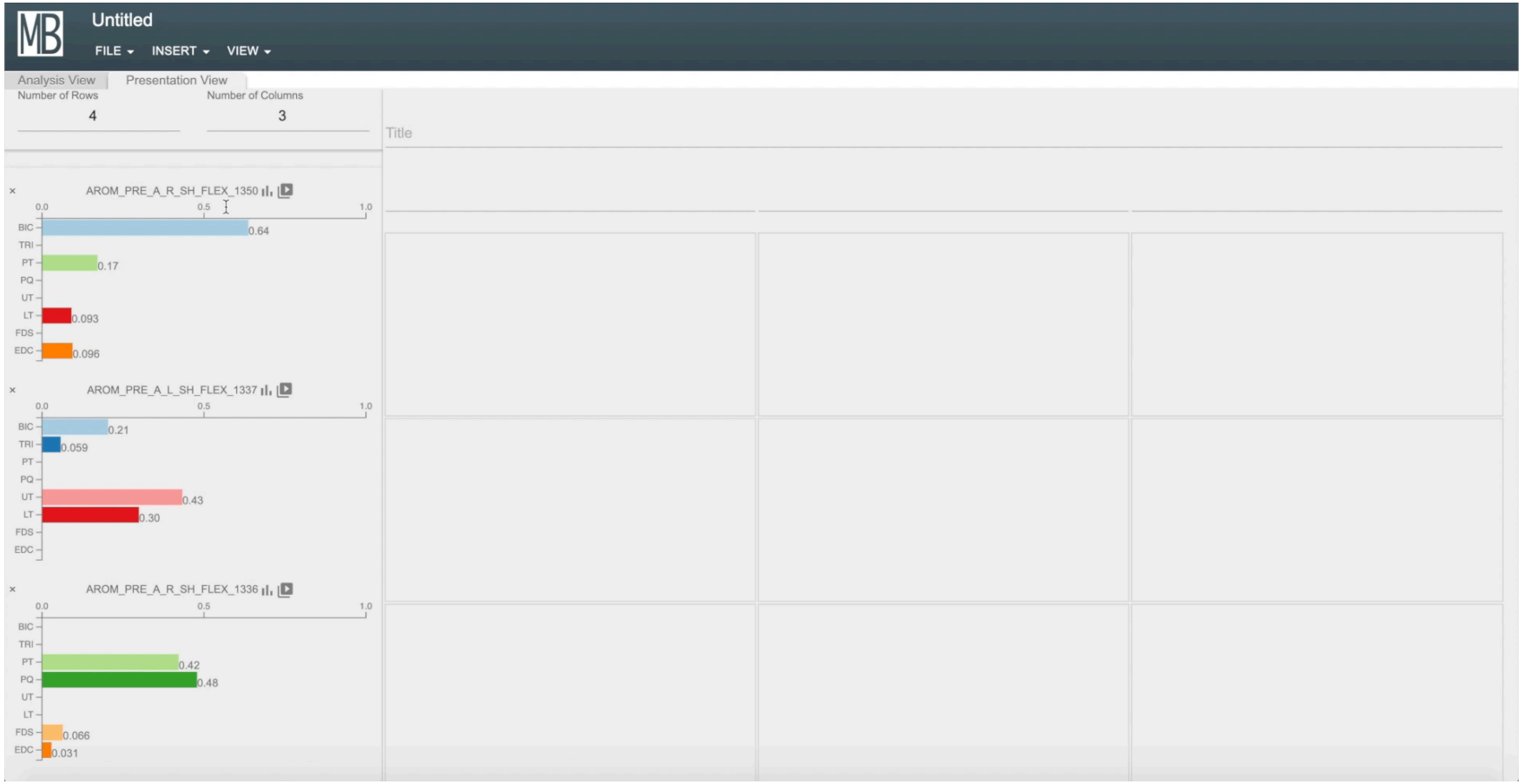


Upper Trapezius Muscles

Lower Trapezius Muscles

Case Study

Usefulness of Trapezius Muscles on Shoulder Motion



Upper Trapezius Muscles

Lower Trapezius Muscles

Case Study

Usefulness of Trapezius Muscles on Shoulder Motion

3 groups of patients

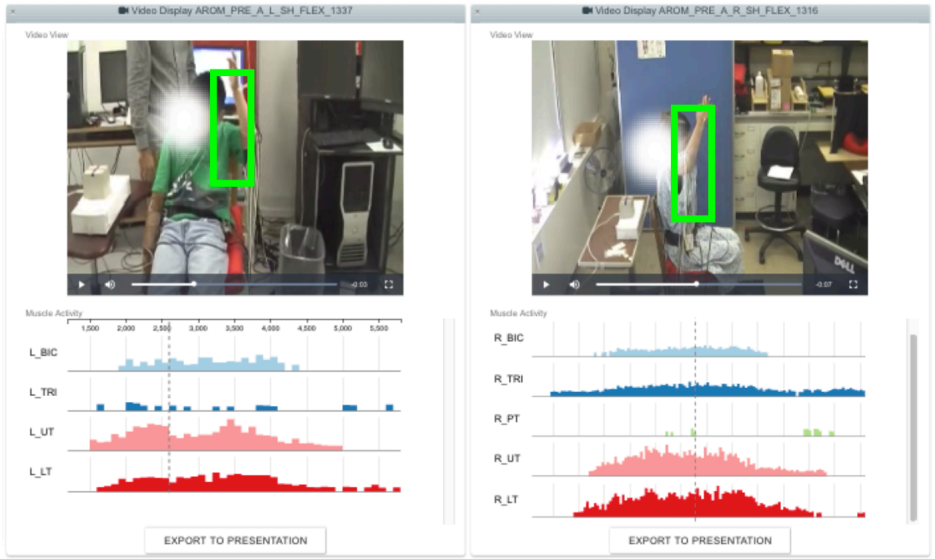
Upper Trapezius Muscles

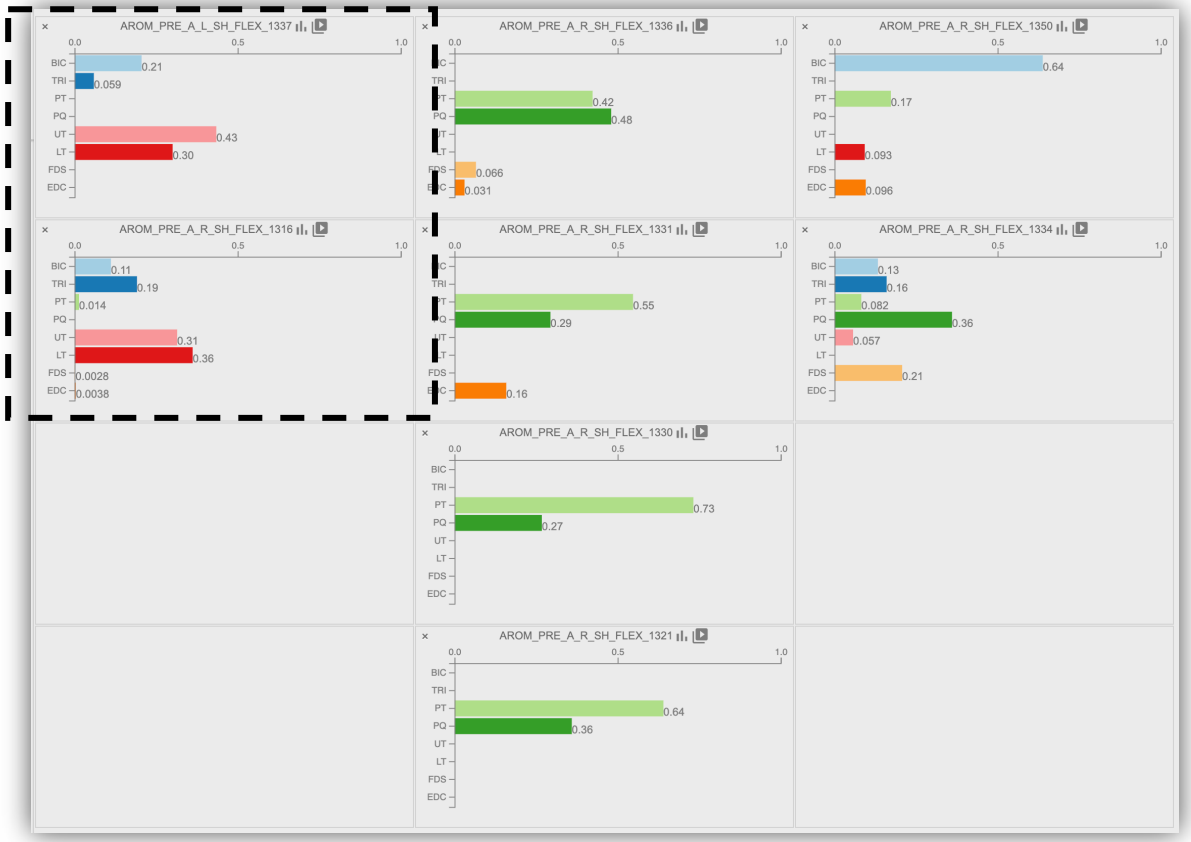
Lower Trapezius Muscles

Case Study

Usefulness of Trapezius Muscles on Shoulder Motion

Patients overfiring their muscles





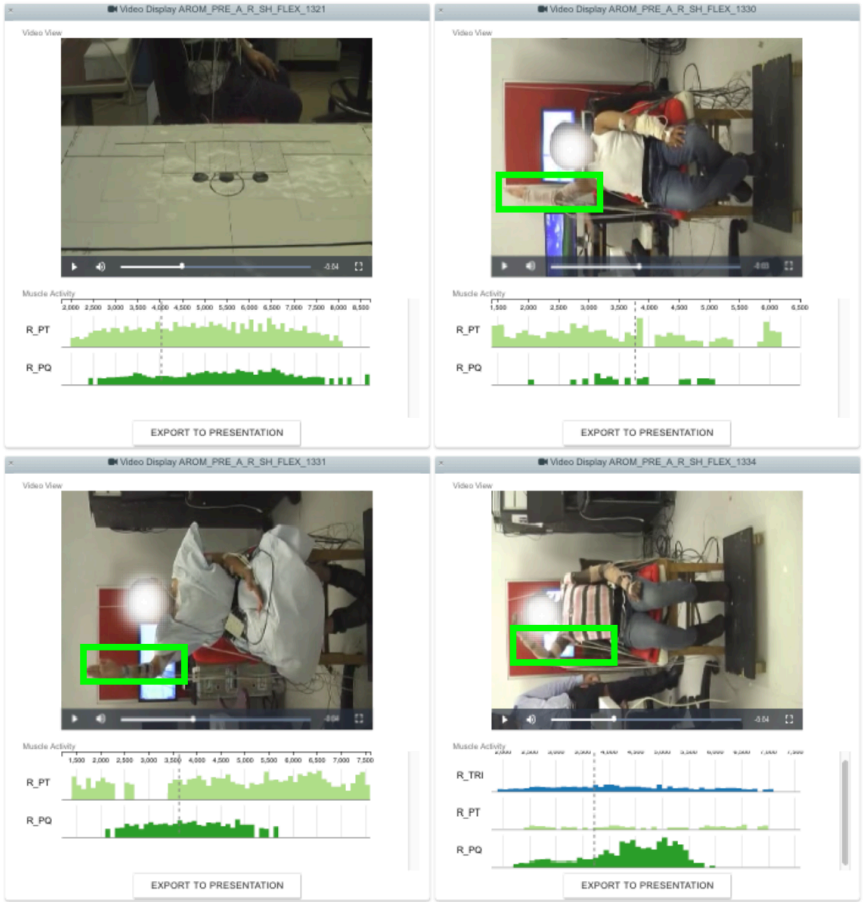
Upper Trapezius Muscles

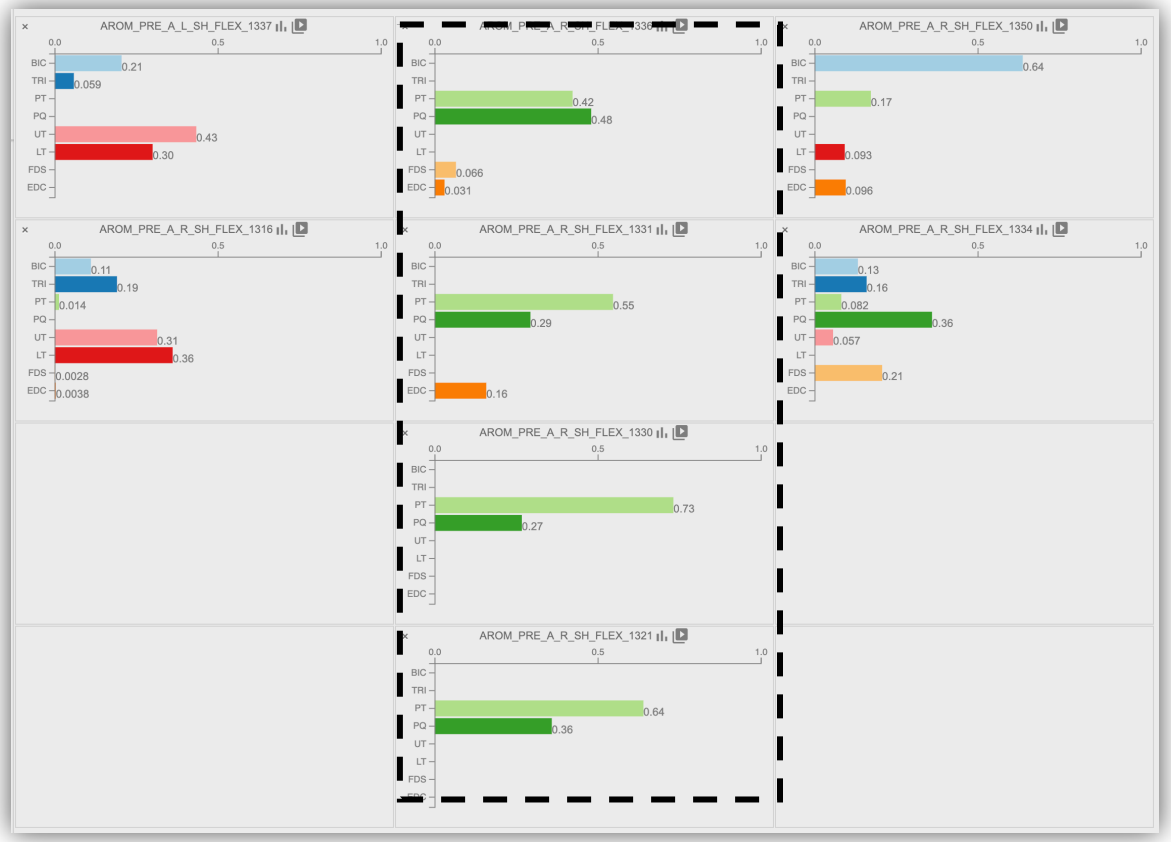
Lower Trapezius Muscles

Case Study

Usefulness of Trapezius Muscles on Shoulder Motion

Patients not using trapezius muscles





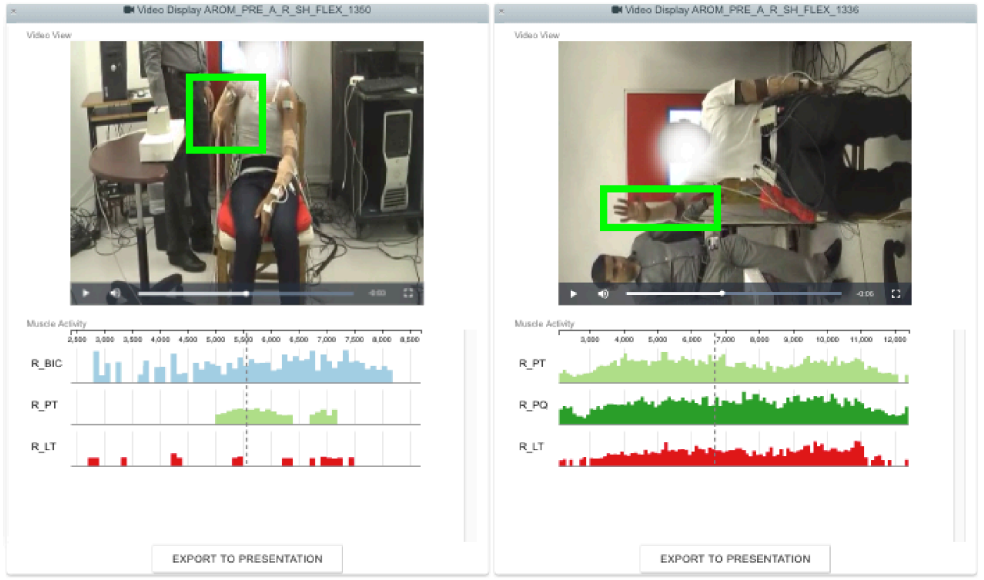
Upper Trapezius Muscles

Lower Trapezius Muscles

Case Study

Usefulness of Trapezius Muscles on Shoulder Motion

Patients using trapezius muscles



Upper Trapezius Muscles

Lower Trapezius Muscles

Conclusion

Conclusion

Takeaway and Future Work

1. Task analysis on medical domain requires extra effort
2. Reducing cycle time on repeated interactions is useful
3. More statistical analysis is required to be able to submit to medical journal (ongoing)

Thank you



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