

Biomechanics Analysis and Reporting Application User Manual

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Version 1.0

Contents

Intent.....	3
Scope.....	3
Overview	3
Future Work.....	4
Main Application.....	4
Database Search	4
Working Database.....	5
Processing	5
Analysis	5
Review.....	5
Statistics.....	5
Export.....	5
Configuration	6
Analysis Modules	6
Custom	6
False Nearest Neighbor.....	7
Recurrence Quantification Analysis	7
Time Lag.....	7
Loading Data into BAR	7
Overview	7
Process Modules	7
Groupings.....	7
Merge.....	7
Segment	7
Treatment	7
Review Modules.....	7
Raw.....	7
False Nearest Neighbor.....	7
Recurrence Quantification Analysis	7
Time Lag.....	8
Quality Review	8

Intent

The creation of this application hopes to establish a generalized framework by which scientists in the biomechanics community conduct their data processing and analysis. The intent is that this will facilitate data analysis and reporting by making the process easier for students with varied backgrounds, and by enhancing the repeatability of analytical procedures. The framework provides a base-level application that others can use as-is or build upon with their own sources and methods.

Scope

The base-level of the application includes 1) loading of data, 2) processing and analysis, 3) graphical and quality review and 4) export of the data. Its design was meant to be open to varied methods used in the study of human movement. Ultimately, these methods are not all that dissimilar to methods in other fields. It is likely those outside the realm of biomechanics would also find this application useful.

Some aspects of data processing are outside the scope of the application. These may require dedicated hardware or complex software solutions, involve high performance computing or complex modeling and simulation.

Overview

The app has a main application called BAR_App. This will handle all the configuration settings and dynamic use of modules. Modules are considered any mlapp- or m-file that is dynamically used by the app. Some modules are considered central to the application. These include 1) process_Groupings, 2) process_Merge and 3) review_RAW. Modules fit into categories named 1) Analysis, 2) Load, 3) Process and 4) Review. These are also the major folders used by the app. Another folder called Subroutines is meant to house low level functions that may have widespread use across other modules.

Analysis modules are similar in function to Process modules but differ in scope and intent. Analysis modules are for complex analyses that are more likely to be other mlapp-files. These modules allow users to perform complex operations with significant user input. They often will take time series or aggregate data and produce single metrics or statistics.

Load modules are mostly functions that read data from a file, package it into a BAR App data structure and load it into the app. They are organized using the file and equipment type. The file type must match the file type of the target file however the Equipment type can vary. An example could be load_h5_APDM1Lumbar.m and load_h5_APDM1Raw.m. Both read data from the same h5 file but the first reads only the lumbar data while the later reads only the raw data.

Process modules are more general purpose analysis methods. These may include segmentation or other treatment like filtering. They are not considered the end of a processing step and would produce data that is later used in an Analysis module. Process modules are more general in that they may proceed multiple Analysis Modules, whereas the later is considered an end point.

Review modules are meant for data visualization. These modules should be mostly mlapp-files that can dynamically produce general or specific figures of the data. For most users the review_RAW.mlapp

module it hoped to be sufficient. For most complex analyses there will be a corresponding Review Module that produces specific figures describing the analysis results.

Future Work

As of December 12, 2022, the app will only function as hoped within the MATLAB environment. It was hoped that the code could be compiled into an executable that could dynamically use different functions and scripts. This has turned out to be impossible as those scripts need to be compiled at runtime, or a MATLAB server is used. Instead of working on this further the app has been developed as a MATLAB App that can be shared with other MATLAB users.

Main Application

This section will describe the `BAR_App.mlapp` file that is central to the BAR App. It controls the 1) locating and 2) loading of data, 3) processing, 4) analysis, 5) review and 6) export. These functions are mostly accomplished by the different tabs within the app.

Database Search

Database Search is where all of the file handling will be performed. This starts by setting the Working Database.¹ The button will allow a user to select a folder. The app will then check that certain folders exist within it. These include folders named Export, Figures and Results. Export is used as the default target folder when exporting data from the main application. Figures is used by the review_RAW module and by supported modules as a default folder to save figures to. Results is used to save intermediate data and results. Directories can also be typed into the text field. This will not create subfolders but is useful when quickly changing between Working Directories.

Before files can be loaded the app must know where to look for them. Directories can be entered into the search field², or added through the button³. The app performs a recursive search algorithm that looks through all listed folders and subfolders for the target files. This is generally quick but will be significantly slower on network drives.

MATLAB App v1.0

movement & applied imaging lab **Biomechanics Analysis and Reporting Application**

Database Search | Processing | Analysis | Review | Statistics | Export | Configuration

Select Working Database: R:\PROJECTS\wesens\Data\Analysis\Senderling\WESENS EMG

Add Directory to Search: R:\PROJECTS\wesens\Data\Analysis\Senderling\WESENS EMG\Data

Select file extension of the data files: txt Select equipment the data was recorded from: V3D

Enter specific strings separated by commas to filter the files selected.

Include: Exclude:

Find Load Merge Move Copy Identify Groups Save Current Data

File Name	Folder	Size (MB)
W002_20210324_R_mocap....	R:\PROJECTS\wesens\Data\Analysis\Senderling\W...	6.8440
W002_20210715_R_mocap....	R:\PROJECTS\wesens\Data\Analysis\Senderling\W...	22.0370
W002_20210830_R_mocap....	R:\PROJECTS\wesens\Data\Analysis\Senderling\W...	21.4660
W003_20210211_R_mocap.txt	R:\PROJECTS\wesens\Data\Analysis\Senderling\W...	10.3720
W003_20210518_R_mocap....	R:\PROJECTS\wesens\Data\Analysis\Senderling\W...	10.6620
W003_20210723_R_mocap....	R:\PROJECTS\wesens\Data\Analysis\Senderling\W...	10.7740
W009_20210420_R_mocap....	R:\PROJECTS\wesens\Data\Analysis\Senderling\W...	10.7940
W009_20210811_R_mocap.txt	R:\PROJECTS\wesens\Data\Analysis\Senderling\W...	11.3030
W009_20210922_R_mocap....	R:\PROJECTS\wesens\Data\Analysis\Senderling\W...	21.6550
W010_20210712_R_mocap....	R:\PROJECTS\wesens\Data\Analysis\Senderling\W...	21.9790

021 formatted 140 of 155
021 formatted 150 of 155
008 results formatted for export and displayed in table
007 results exported

Working Database

Processing

Analysis

Review

Statistics

Export

Configuration

Analysis Modules

The follow section describes the different modules available in the current release. Each section starts with 1) a brief description of the module, 2) assumptions regarding the origin of the data, and 3) a description of the results and what their intended use was.

Custom

QST

The Quantitative Sensory Testing (QST) module is a single script that processes specific experimental data recorded at the BU MoveLab. The method itself does not require any user input and allows the results to be collected into a single file.

Assumptions

Technically this script could run on any data loaded into the BAR App but it is expecting xlsx-Medoc data types. This data was recorded from Medoc software and exported as an xlsx file. The procedure was a pressure-pain sensitivity test. In this test an algometer is used to apply pressure to an anatomical landmark. As that pressure is increased at a set rate the subject presses a trigger to indicate the first sensation of slight pain. The xlsx-file will contain information for the pressure, sampling times and the button press. It will also contain information on the sequence and trial numbers, and meta data related to the test.

Results

The script will produce the following results.

Variable	Intent	Description
sequenceN	Experiment descriptive	This is the number of the Program Sequence in Medoc that the data comes from. This allows a user to identify a result and trace which trial it came from.
trialN	Experiment descriptive	This is the number of the Program Trial in Medoc that the data comes from. Each Program has a Sequence and within each Sequence are Trials. This allows a user to identify a result and trace which trial it came from.
valuePeak	Results metric	This is the absolute peak of the recorded pressure.
valueEvent	Results metric	This is the instantaneous pressure at the time of the button press.
rSquaredAdjusted	Quality metric	This is an Adjusted R^2 that describes how well the pressure data fits a linear line. The application of pressure it meant to increase at a set linear rate. Deviations from a linear rate will result in a lower value and indicate lower quality methods.

slope	Quality metric	This is the slope of a linear line fit to the data. The pressure should be applied at a set rate. This slope is that rate.
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False Nearest Neighbor

Recurrence Quantification Analysis

Time Lag

Loading Data into BAR

Overview

Process Modules

Groupings

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Raw

False Nearest Neighbor

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Appendix A Data Types