

## General information

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## Summary

This package contains MATLAB files that use the least-mean-squared-error (LMSE) algorithm to fit a two state model of motor learning to behavioral data. This algorithm identifies a parameter set that minimizes the squared error between the model fit and the behavioral data. This minimization identifies the parameters that maximize the likelihood function for a model of learning where noise is present only in the production of a movement, not the planning of a movement. For a more realistic system with noise in both processes, an Expectation Maximization (EM) can be used.

More information concerning EM, LMSE, and two state models of learning is available in:

Albert ST, Shadmehr R (2017) Estimating properties of the fast and slow adaptive processes during sensorimotor adaptation. *J Neurophysiol*.

The article is provide for your convenience in this package.

## Version

This version fits data using LMSE. It is compatible with paradigms that include/exclude error-clamp trials as well as set breaks. To model paradigms that contain no set breaks, use Version 1.1.

## Contents

This package includes the following files:

### *LMSE.m*

This function coordinates the LMSE algorithm. It calls *fmincon* to minimize the squared error between the prediction of a noise-free model and the actual behavior in a constrained parameter space.

### *tutorial.m*

This file is a MATLAB script that illustrates how to fit a two-state model to a data set using LMSE. It is intended to provide an overview of how to use this package. The script simulates data according to a two-state model. Next, this script calls functions that coordinate the LMSE algorithm to fit the two-state model to the simulated data. Finally, the script provides some output of the LMSE results.

### *two\_state\_simulation\_with\_noise.m*

This function is referenced in *tutorial.m*. It simulates a two state model with noise.

### *two\_state\_simulation\_without\_noise.m*

This function is referenced in *tutorial.m*. It simulates a two state model without noise.

*Albert\_Shadmehr\_JNP\_2018.pdf*

This is a copy of the manuscript that describes the EM algorithm and compares it to LMSE for the fitting of behavioral data with a two-state model. All model details and technical details about EM and LMSE can be found [here](#).

### **Getting started**

To use LMSE for your data, the best way to get started and familiar with this MATLAB software is to delve into *tutorial.m*. The comments within this script should hopefully be sufficient to show the general user how to interface with the LMSE software.

For your data, you would likely take the following steps to use the LMSE algorithm. Use the *tutorial.m* script as a template and change the following components.

1. Change the perturbation schedule to match your paradigm (r parameter)
2. Change the error-clamp schedule to match your paradigm (EC parameter)
3. Specify the values of the clamped errors to match your paradigm (EC\_value parameter)
4. Change the set break schedule to match your paradigm (SB parameters)
5. Replace the simulated data with your own behavioral data (y parameter)
6. Modify the parameter boundaries for the LMSE fit (search\_space parameter)
7. Modify the constraints relating the two-state model parameters (constraints parameter)
8. Specify an initial parameter guess for the algorithm (IC parameter)