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Web Theon

USER MANUAL

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Introduction

This document is intended to be used by someone who intends to use the software without modifying it. There is a technical documentation available to reference if the user wishes to modify the source code. The widget may look different when inserted in a web page, but the functionality will remain the same. If the information in this guide is insufficient, please contact either Dr Will Christian wjrc@liverpool.ac.uk or Finlay Haggart.

Background

Orthogonal decomposition is a technique for reducing the dimensionality of 2D data fields. These data fields may consist of any type of data, such as image data, strain fields or displacement fields. The data is decomposed into a set of real valued coefficients using a set of orthogonal kernel functions. The coefficients are then collated into a feature vector. A reconstruction of the original data can be obtained by multiplying each of the kernels by their associated coefficient in the feature vector. By using more coefficients, a better reconstruction can be obtained. A detailed description of the mathematics behind orthogonal decomposition can be found in [2]. For smooth data fields (such as most strain and displacement fields measured using experimental mechanics techniques), good reconstructions can typically be obtained using substantially fewer coefficients than there were pixels in the original dataset. The orthogonal decomposition technique has been used as the basis for a validation methodology for finite element models [3, 4] and also as part of a strain-based assessment technique [5].

This software package can be used to decompose and compare 2D spatial data regardless of the geometry of the data field and is capable of importing data from a range of different filetypes. The package can be used to perform simple image operations, such as rotating and cropping data, prior to the decomposition process.” [1]

This software intends to implement the functionality found in the THEON desktop software available at <https://www.experimentalstress.com/>. The original software and this version both implement techniques developed at the University of Liverpool within the Structural Materials and Mechanics Research group.

Starting the Software

This section can be skipped if you are using a built version of Web Theon.

Theon Widget

If the `dist/` folder exists, open the `index.html` file in a browser. If hosting using `nginx` or `apache`, just place the contents of `dist/` into your `/var/www/` folder - or wherever your website code is located. If there is no `dist/` folder, open a terminal, navigate to the folder containing the code and run

```
npm install
```

This will take a minute to run, but when it finishes run

```
npm run build
```

to build the project into the `dist/` folder.

Python Server

To run the python script, run the following from the src/server directory to install the requirements

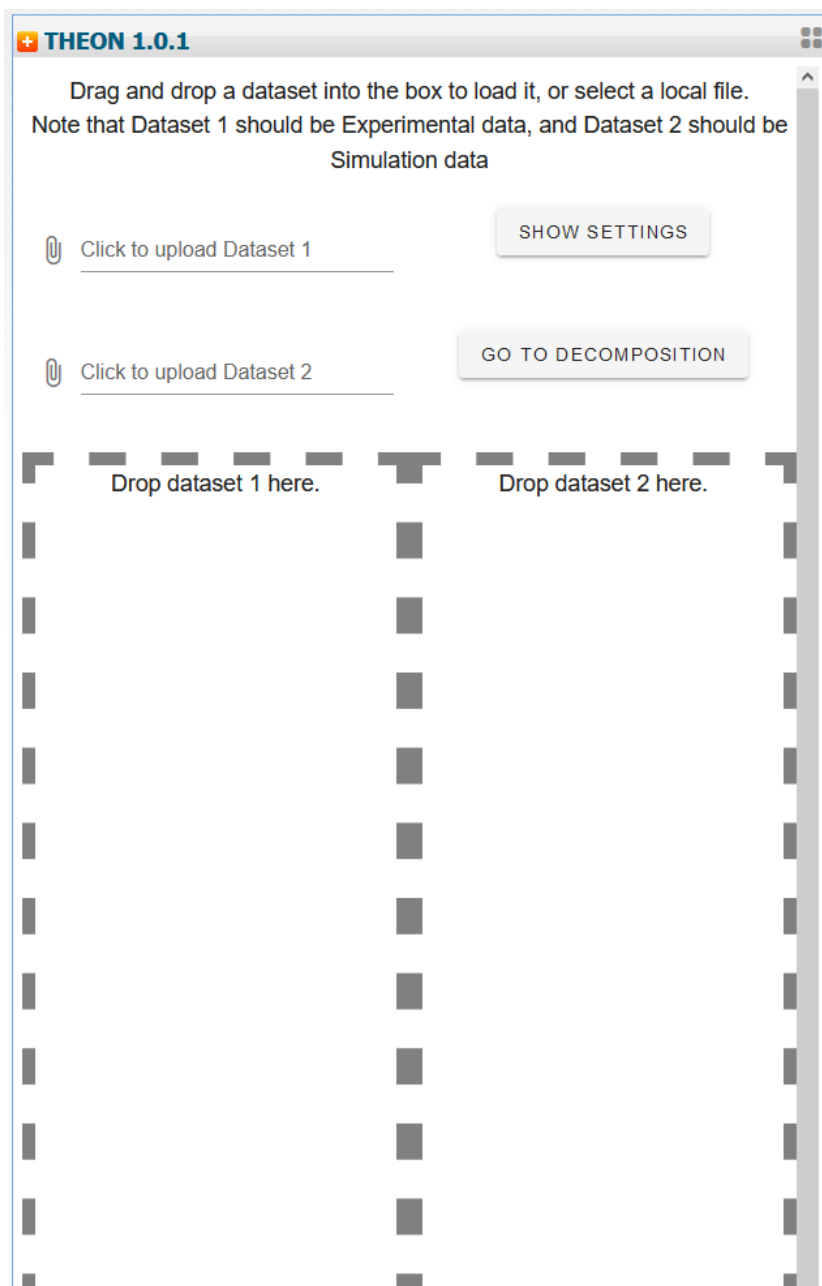
```
pip install -r requirements.txt
```

Then to run the server (default port is 5000)

```
py -m flask --app server run
```

Loading Datasets

The first screen is used solely for loading the datasets into. The datasets can be loaded by either using the file selectors at the top left of the screen, or dragging datasets from a local folder onto the two rectangular panels. The settings panel provides the ability to view individual datasets or both simultaneously. The "Go to decomposition" button will take you to the next panel, the decomposition panel.



Supported input file types

Currently the widget supports the following file formats:

- CSV, consisting of three columns of data representing x , y , and D
- JSON in the format in shown below

```
{  
  "x": [Number, ...],  
  "y": [Number, ...],  
  "D": [Number, ...],  
  "xUnit": String,  
  "yUnit": String,  
  "DUnit": String,  
  "measurementUncertainty": Number,  
  "dateCreated": String,  
  "loadConditions": String,  
  "boundaryConditions": String,  
  "dataType": String,  
  "environmentalConditions": String  
}
```

Carrying out Decomposition

The screenshot shows the THEON 1.0.0 web interface. At the top, there is a header with the text "THEON 1.0.0" and a window control icon. Below the header, there is a text input field labeled "Input the order of Chebyshev polynomials to use" with the value "0" entered. To the right of this field is a button labeled "RETURN TO INPUT". Below the input field, there is a label "1 coefficient". There are three buttons: "UNCERTAINTY SETTINGS" on the left, "DECOMPOSE DATA" in the center, and "EXPORT DATA" on the right. Below these buttons, there is a text instruction: "Press decompose to calculate points in bounds". To the right of this instruction is a button labeled "UPDATE GRAPHS". At the bottom of the panel, there are two dropdown menus, each labeled "Select data to view". Below each dropdown menu are two checkboxes: "Show/Hide" and "Show all points". At the very bottom of the interface, there is a small text footer: "Theon Version 1.0. Created by Will Christian and Finlay Haggar".

This panel allows you to input the order of polynomials to be used for the decomposition, and if the software cannot load an uncertainty value automatically, you can also enter it. Once the polynomial order is entered, press "Decompose Data" to generate the two feature vectors using orthogonal decomposition. These can then be viewed either on their own, or plotted on the same axes with the bounds marked. Graphs available are as follows

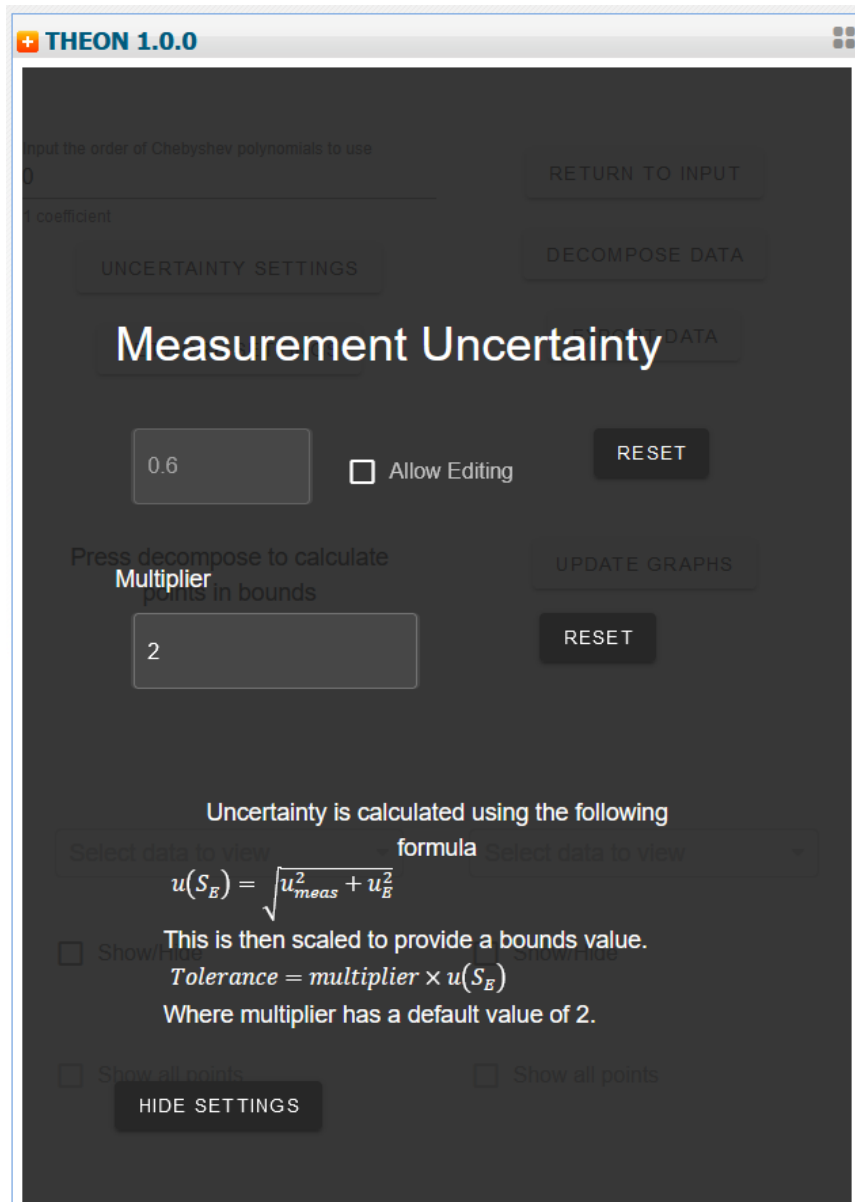
- Original Datasets
- Feature Vectors
- Comparison of Feature Vectors
- Reconstructed Datasets

- Difference between reconstructions and originals (with RMS error)
- Error Clusters

This panel also contains settings which allow you to edit the uncertainty, the network options and provides the ability to export graphs as png files, and export Feature Vectors in the format shown below:

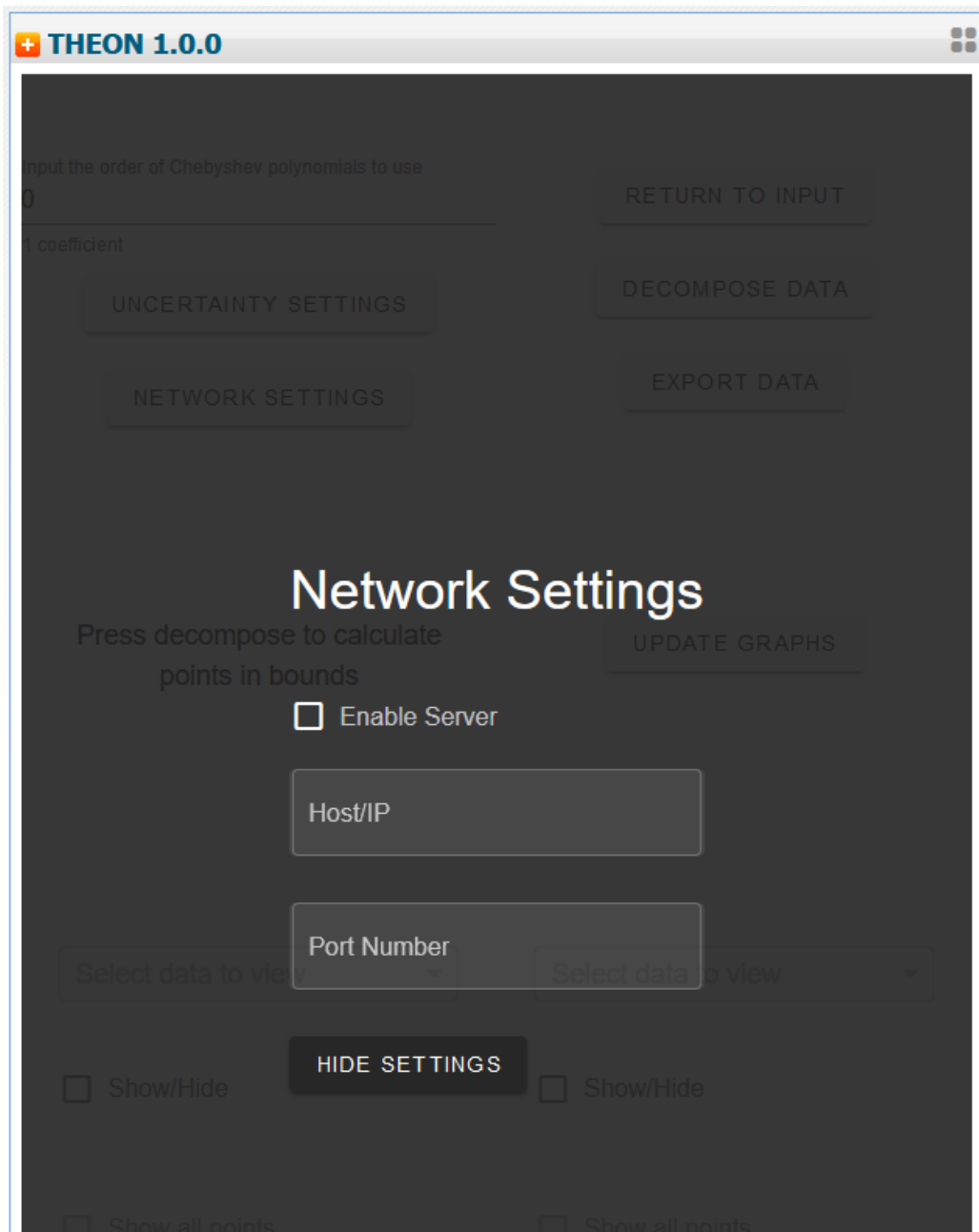
```
{
  "timestamp": String,
  "unixTime": Number,
  "measurementUncertainty": Number,
  "filenames": [String, String],
  "outputStatement": String,
  "featureVector1": [Number, ...],
  "featureVector1Uncertainty": Number,
  "featureVector2": [Number, ...],
  "featureVector2Uncertainty": Number
}
```

Uncertainties



This overlay allows a user to adjust the value of the uncertainty. The equation is taken from [4] (eq 3.3). If there is a value available, it will be loaded automatically, or the user can change it if they wish. u_E^2 is calculated in software and is the uncertainty of the reconstruction of the second dataset.

Networking



If the server is configured and running, decomposition can be handed off to it to speed up the process. To use the server, open the Network Settings menu and enter the hostname and port of the server, (port is by default 5000) then tick the box to use the server.

References

1. Andrew Dean, Brodie Payter, Jacob Curtis, William Christian and Eann Patterson, (2020) THEON Manual v0.9
2. Mukundan R, Ong SH and Lee PA, (2001) Image analysis by Tchebichef moments, IEEE Transactions on Image Processing, 10(9), 1357-1364
3. Sebastian C, Hack E and Patterson EA, An approach to the validation of computational solid mechanics models for strain analysis, Journal of Strain Analysis for Engineering Design, 48(1), 36-47, 2013
4. European Committee for Standardization, (2014) CWA 16799:2014, Validation of computational solid mechanics models
5. Christian WJR, DiazDelaO FA, Patterson EA, (2018) Strain-based damage assessment for accurate residual strength prediction of impacted composite laminates”, Composite Structures, 184, 1215-1223