

Mpm Tutorial

December 29, 2019

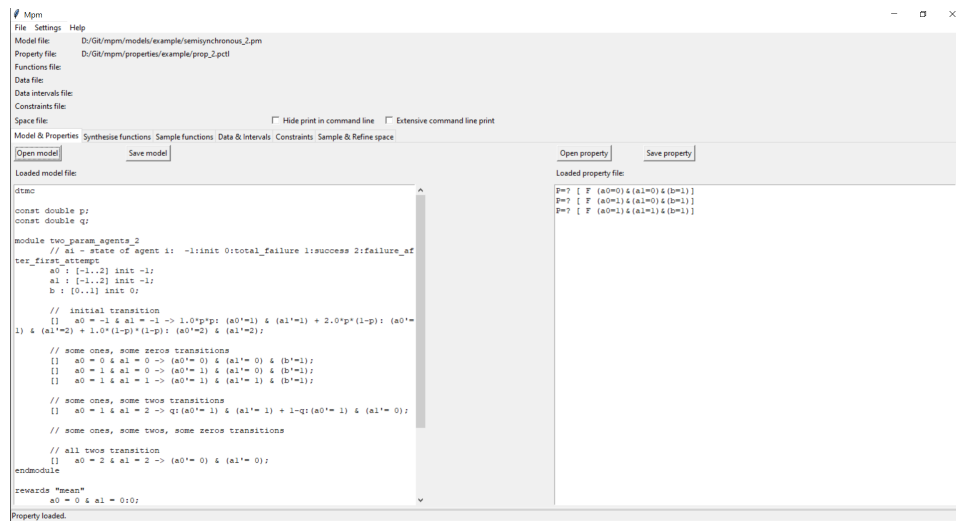
First use

In this tutorial, we show the main workflow of Mpm. It consists of nine use-cases introducing separate functionality of respective tab of GUI:

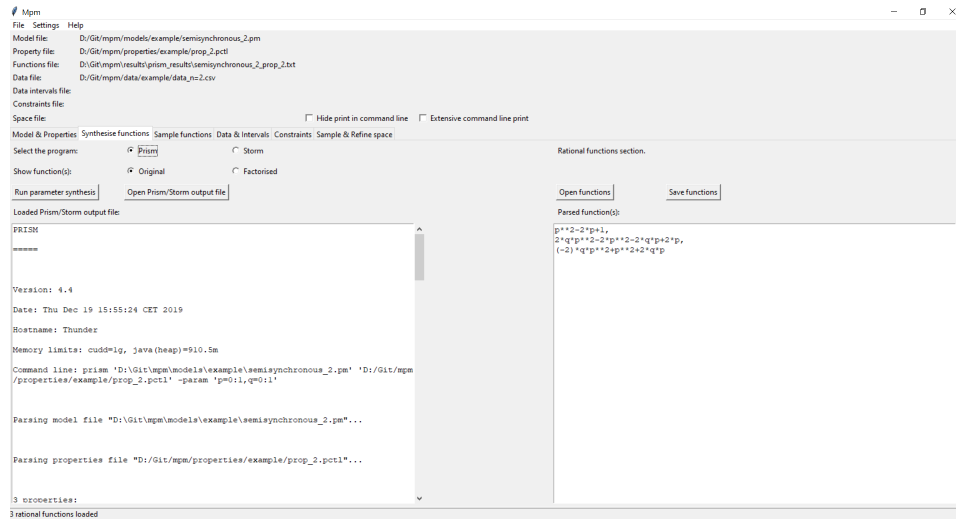
1. Load model and properties
2. Synthesise parameters
3. Load data
4. Optimize parameters
5. Sample functions
6. Calculate constraints
7. Sample space
8. Refine space
9. Metropolis-Hastings

As an example input, we use parametric discrete-time Markov chain population model of stinging behaviour of two bees and Probabilistic Computation Tree Logic properties of reaching respective number of stinging - zero, one, or two - as presented in [1]. We reuse presented data point representing the experimentally observed frequency of respective property - 0.04, 0.02, 0.94.

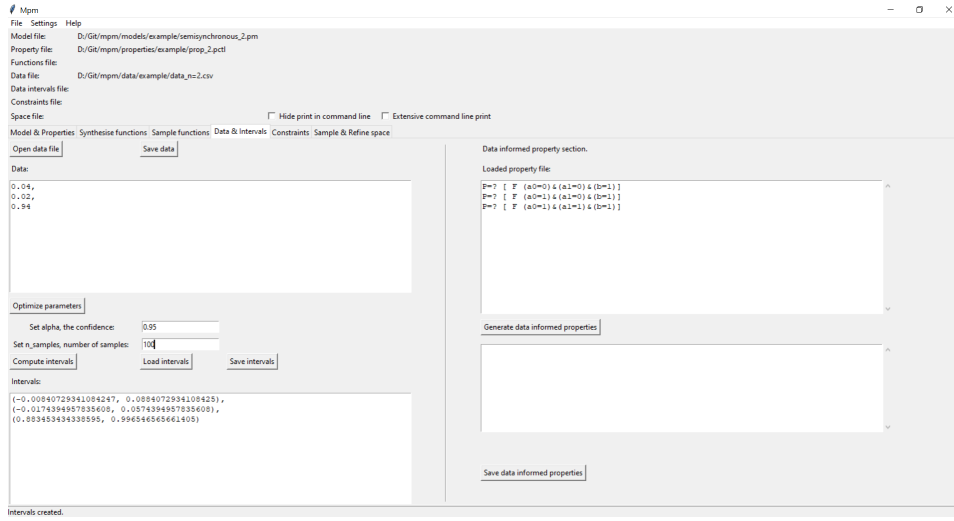
1. When you open Mpm GUI, you will see - Model and properties - tab. Click on **Open model** button and select *example/semisynchronous_2.pn* file to load the model. Then click on **Open properties** button to load the properties and select *example/prop_2.pctl* file.



- After the model and properties are loaded, you can run parameter synthesis. To do so, move to the second Tab and click on **Run parameter synthesis** button. The PRISM output file is shown on the left and rational functions parsed from the output on the right:

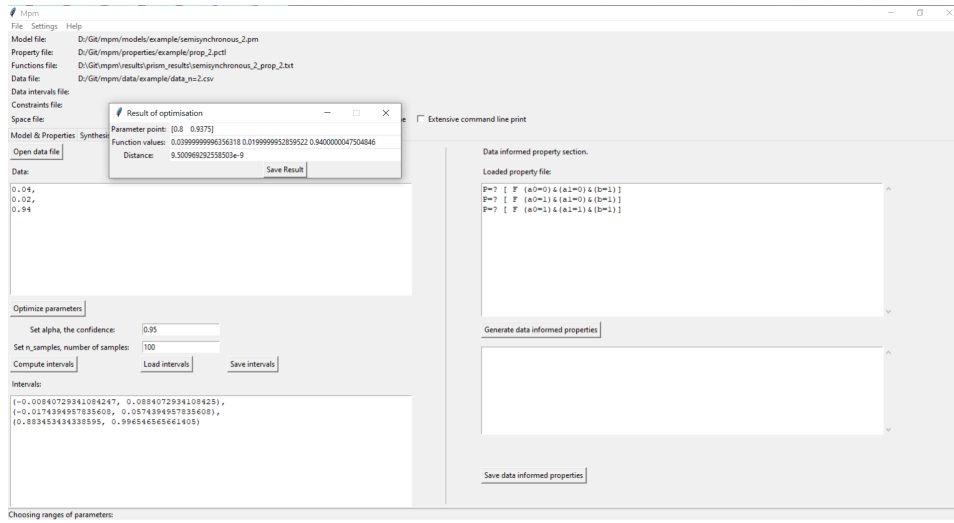


- Now proceed to Tab 4 (skipping the third one). Here press **Open data** button and select *example/data_n = 2.csv* file¹ to load data. Then press **Compute intervals** button (left bottom). Now you have loaded all necessary inputs:

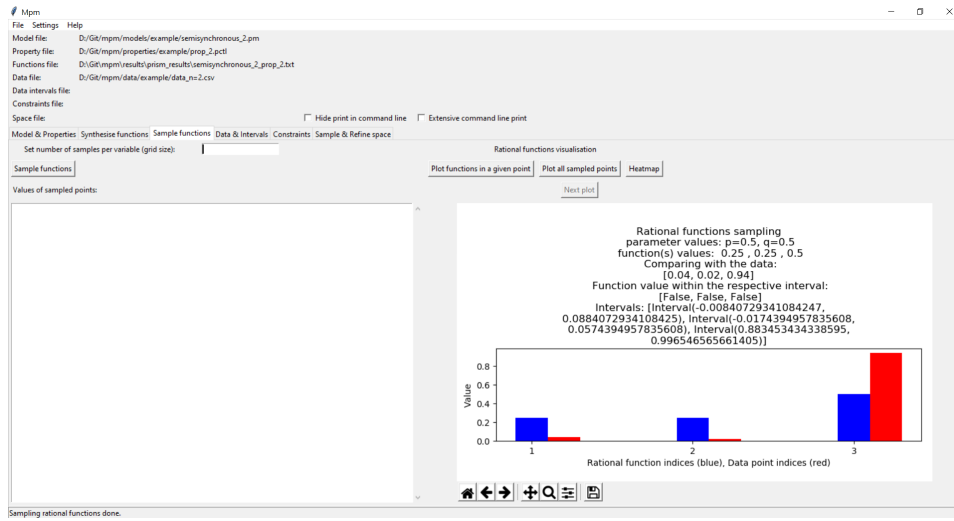


¹to see .csv file in explorer, please filter .csv or all files

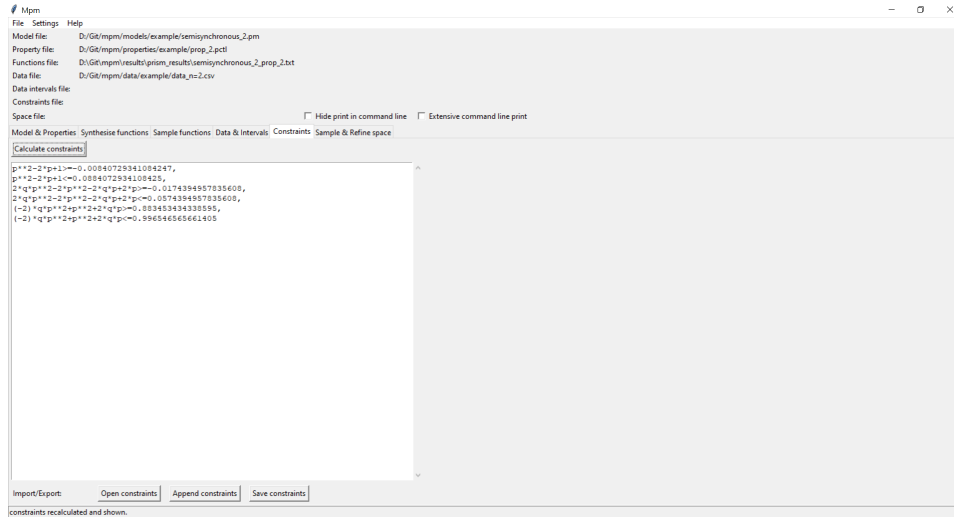
4. While still on Tab 4, you can optimize parameters of the rational functions for minimal distance to data. Just press **Optimize parameters** button and press **OK** selecting default intervals of respective parameter to search in that domain. Now a new window with the results, parameter values, values of rational functions in this point and the distance between functions and data pops out:



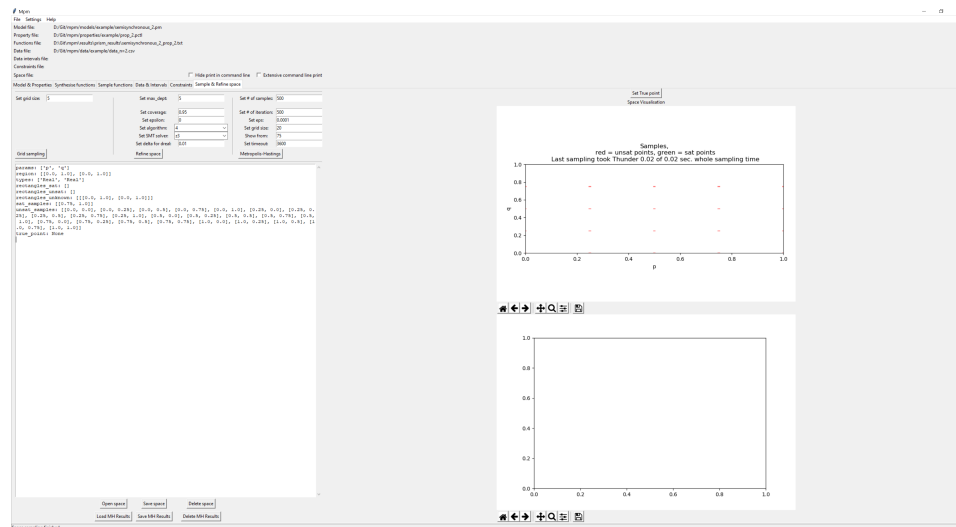
- After finishing step 3, you can compare values of a computed rational function with the loaded data. To do so, click on the Plot functions in the given point and select the desired point, for example, 0.5, 0.5. A plot showing the respective values is visualised:



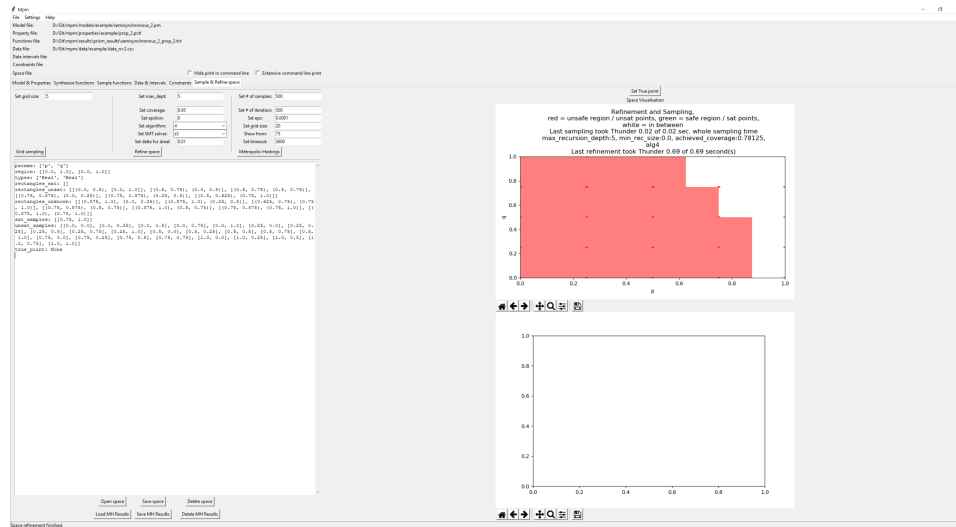
- Finally, you can merge rational functions and intervals to create constraints. Go to Tab 5 and press **Calculate constraints** button to see the results:



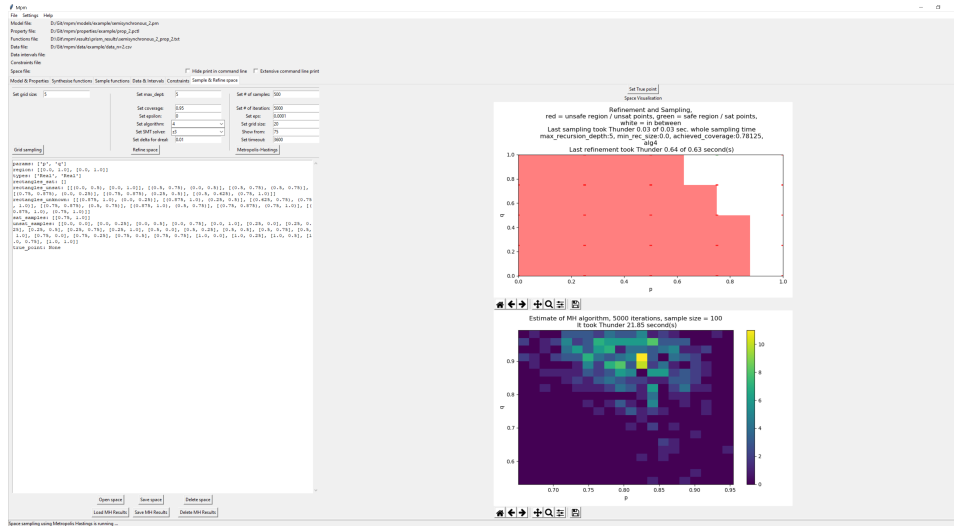
7. Now we are ready to run the rest of the analysis. To search for points in parameter space which are within the calculated intervals press Grid sampling showing the result:



8. Moreover, you can obtain global results by clicking on **Refine Space** button:



9. As the last part, you can run Metropolis-Hastings by pressing the button with the corresponding name and selecting a point in the parameter space to start the search from it. The result is shown in the bottom figure:



Bibliography

- [1] Hajnal, M., Nouvian, M., Šafránek, D., Petrov, T.: Data-informed parameter synthesis for population markov chains. In: Češka, M., Paoletti, N. (eds.) *Hybrid Systems Biology*. pp. 147–164. Springer International Publishing, Cham (2019)