Physiovalues developer documentation

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Introduction

This is user's guide and developer's documentation of the open-source project www.physiovalues.org. The project consist of these applications:

- sim.physiovalues.org Online web simulation tool allows to show several screens, manipulate selected parameters and perform simulation. The idea and details was described by T.Kulhánek et al. [1].
- app.physiovalues.org Online web parameter estimation tool allows to perform parameter estimation using "curve-fitting" method and genetic algorithm selecting values of parameters which are simulated. The details and results were described by T.Kulhánek et al. [2].

References

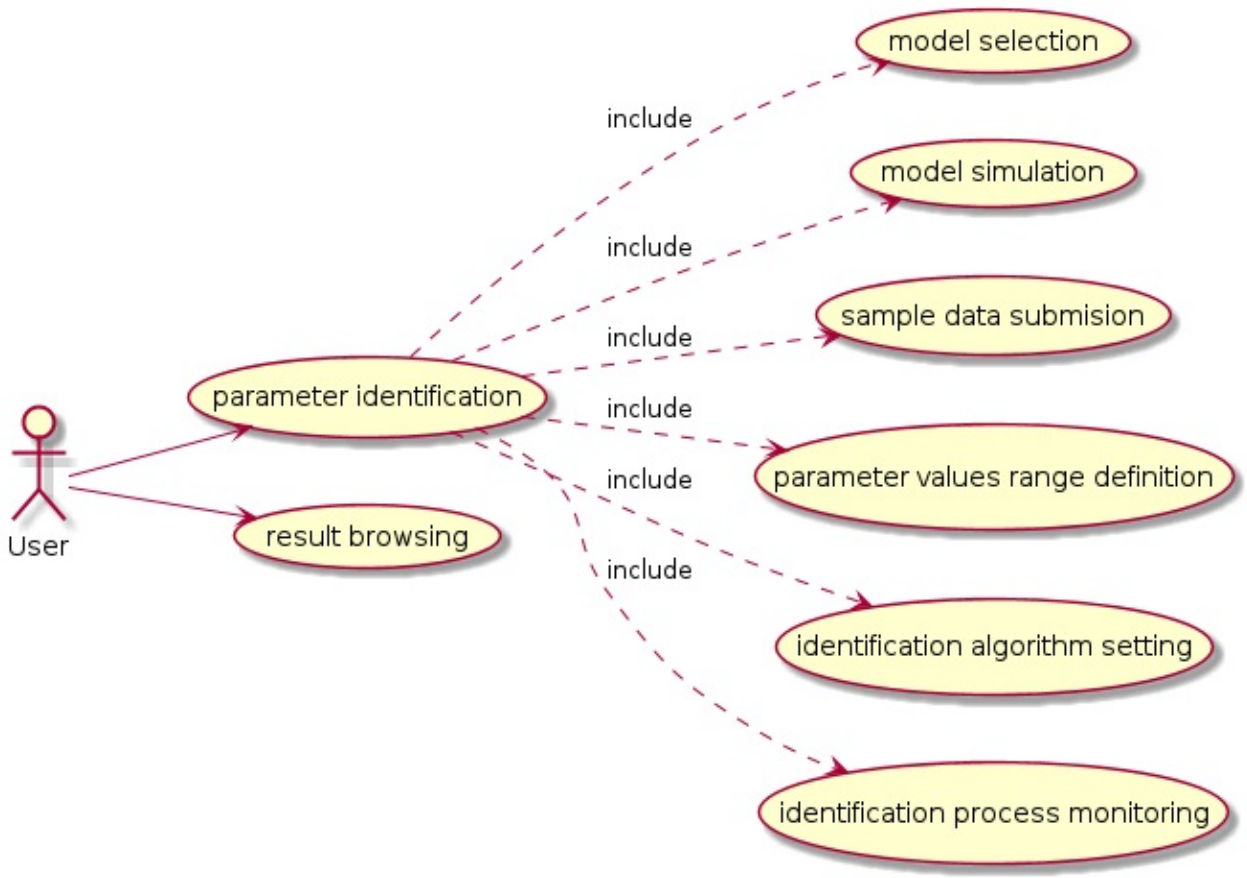
[1]. T. Kulhánek, F. Ježek, M. Mateják, J. Šilar, P. Privitzer, M. Tribula, et al., RESTful Web Service to Build Loosely Coupled Web Based Simulation of Human Physiology, Trans. Japanese Soc. Med. Biol. Eng. 51 (2013) R–32. doi:10.11239/jsmbe.51.R-32. ↩

[2]. T. Kulhánek, M. Mateják, J. Šilar, J. Kofránek, Parameter estimation of complex mathematical models of human physiology using remote simulation distributed in scientific cloud, in: Biomed. Heal. Informatics (BHI), 2014 IEEE-EMBS Int. Conf., 2014: pp. 712–715. doi:10.1109/BHI.2014.6864463. ↩

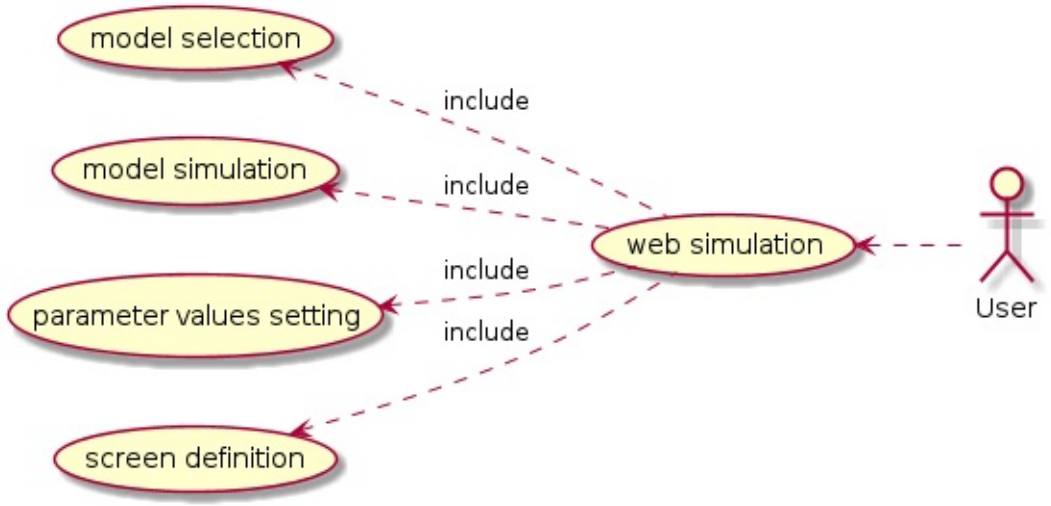
Project Structure

The system provides these use cases: *Parameter Identification*, *Web Simulation* and *Parameter Sweep analysis* sharing common features.

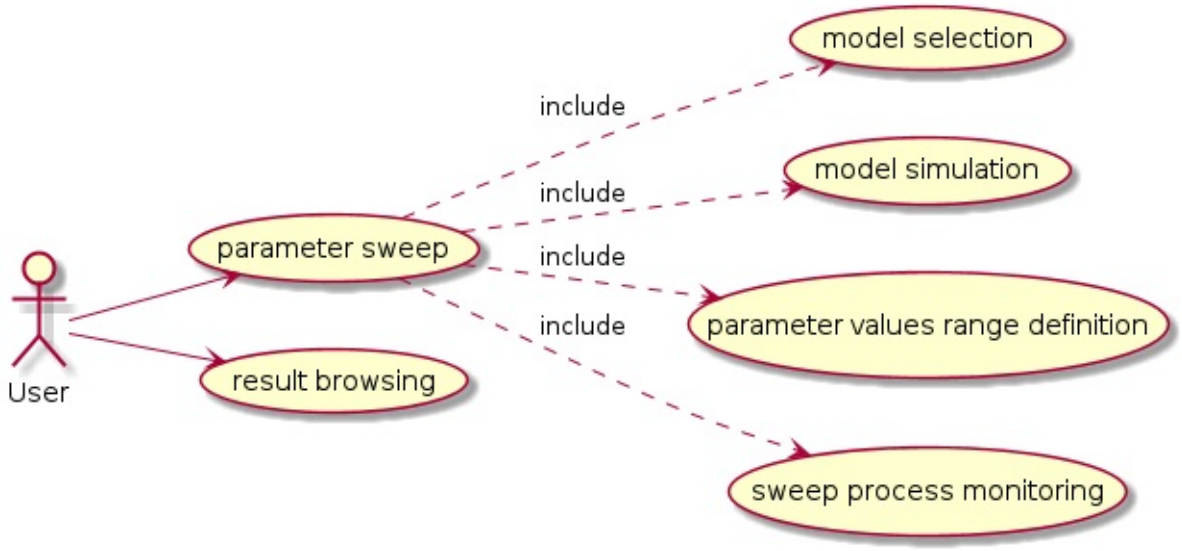
```
@startuml
left to right direction
User --> (parameter identification)
(parameter identification) ..> (model selection) : include
(parameter identification) ..> (model simulation) :include
(parameter identification) ..> (sample data submision) : include
(parameter identification) ..> (parameter values range definition) : include
(parameter identification) ..> (identification algorithm setting) :include
(parameter identification) ..> (identification process monitoring) :include
User --> (result browsing)
@enduml
```



```
@startuml
left to right direction
(model selection) <.. (web simulation) :include
(model simulation) <.. (web simulation) :include
(parameter values setting) <.. (web simulation) :include
(screen definition) <.. (web simulation): include
(web simulation) <.. User
@enduml
```




```
@startuml
left to right direction
User --> (parameter sweep)
(parameter sweep) ..> (model selection) : include
(parameter sweep) ..> (model simulation) :include
(parameter sweep) ..> (parameter values range definition) : include
(parameter sweep) ..> (sweep process monitoring) :include
User --> (result browsing)
@enduml
```



Server modules for parameter identification

from https://github.com/TomasKulhanek/Physiovalues

`doc` documentation
`src` source codes od server modules
`test` tests

- `src/IdentificationAlgorithm/*` MATLAB files utilizing Global Optimization Toolbox and genetic algorithm ga()
- `src/RestMasterService/*` web app with front-end (HTML, AJAX javascript) and backend (C# .NET) to control identification process
- `src/SimulatorBalancerLibrary/*` .NET DLL library to balance simulation requests going from MATLAB to remote computation nodes
- `BOINC/*` BOINC related scripts and customization to configure BOINC server with dedicated

Further details in chapter server_modules.md.

Server modules for web simulation

from ...

`WebSimulator/*` web app with front-end (HTML,AJAX javascript) and backend (C# .NET) to define screen of specific simulator and show web simulators.

Further details in chapter server_modules.md.

Computation node

from https://github.com/TomasKulhanek/Physio.FmiRestService

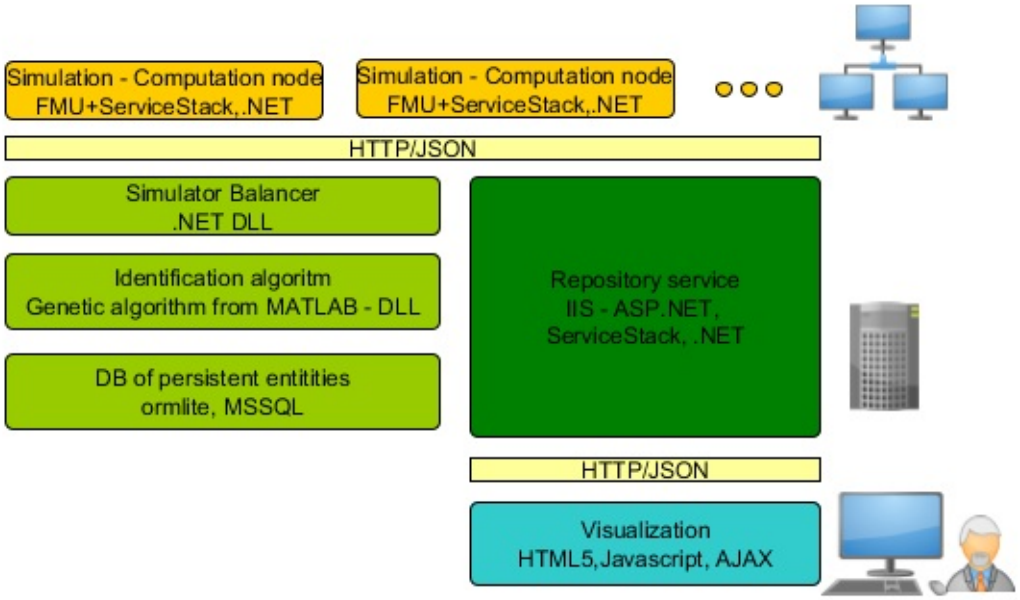
- `BatchWrapperTest/*` unit test form FmiBatchWrapper
- `FmiBatchWrapper/*` console application for performing FMI simulation, parameter sweep arguments, BOINC client application
- `FmiRestServiceWrapper/*` local server giving RESTful web service for performing simulation via HTTP
- `TestFmiRestService/*` unit test for FmiRestServiceWrapper

Further details in chapter computation_node.md.

FMI driver

for managed .NET (C#,C++) and for Control Web driver [1] from https://github.com/TomasKulhanek/Physio.FmiDriver4CW

- `doc/*` instruction for control web driver instalation and helper files generation
- `include/*`
- `lib/*` binaries of fmi library from jmodelica[2]
- `project/*` - ms visual studio project files
- `src/*` - C,C++ sources
- `test/*`
- `thirdparty/*` - sources of fmi library from jmodelica



1. http://www.mii.cz/ ↩

2. http://www.jmodelica.org/FMILibrary ↩

Server Modules

from https://github.com/TomasKulhanek/Physiovalues

`doc` documentation
`src` source codes od server modules
`test` tests

Identification Algorithm

`IdentificationAlgorithm/` Contains MATLAB files utilizing Global Optimization Toolbox and genetic algorithm ga().

`identify_main.m` Main function, loads DLL to perform simulation e.g. SimulatorBalancer.DLL (which delegates simulation request to available computation nodes via HTTP and REST api), reshapes the array of parameter and variables, initializes the log files (absolute paths are wired) and performs minimalization

`identify_minimize.m` prepares data for genetic algorithm and performs ga() call with callback to identify_objective

`identify_objective.m` is called by the genetic algorithm with set of values of parameters to be evaluated. This function calls identify_evalModel and identify_ssq to perform simulation and quantify distance from sample data.

`identify_simulate.m` is called by identify_evalModel. Executes the call from .NET DLL of mySimulator.Simulate().

compilation

This module must be compiled using MATLAB Compiler as .NET Assembly - IdentificationAlgorithm.prj contains preconfigured functions which will be in the .NET Assembly class available for calling from .NET. After compilation the resulting DLL can be used in any application. On other computer the Matlab Compiler Runtime is needed to be installed.
The compilation was done and tested with MCR 8.1 32-bit.

Web Application

C# ASP.NET web application. Uses these external package for .NET: ServiceStack, SignalR; and Javascript: JQuery, Dygraph, Handsontable.

`RestMasterService/*` contains web application with front-end (HTML, AJAX javascript) and backend (C# .NET) to control identification process.
The back-end is based on REST service utilizing ServiceStack framework and controlin/notification baased on SignalR framework.

`WebApp/GenericUI.html` `WebApp/GenericUIen.html` -HTML with embeded Javascript code utilizing jquery,signalr,dygraph,handsontable etc. to collect inputs from web interface, start identification process, show notification from server and browse results.

`WebApp/IdentifyStateTicker.cs` Performs external call of matlab library to estimate parameters, pass all arguments from the user, notify about the changes the clients. SignalR is used to notify all connected clients about the changes of computation, errors, etc.

`Webapp/IdentifyStateHub.cs` Interface for controlling the computation using SignalR.

`ComputationNodes/Workers.cs` RESTful web service utilizing ServiceStack processing the requests on HTTP URLS:

- `/workersByName/{ModelName}`
- `/workers`
- `/workers/{Id}`

Computation node register it's models by PUT on `/workers/{Id}` or POST on `/workers`. All registered workers can be listed via GET on the above URLs.

`ComputationNodes/Results.cs` RESTful web service utilizing ServiceStack processing the requests on HTTP URLS:

- `/results` POST - registers new result, GET gets all results
- `/results/{Id}` PUT - register new,update existing with an ID, GET - gets existing result with Id

compilation

The Visual Studio 2013 Solution - `RestMasterService.sln` can be used for compilation of the C# .NET modules.

Simulator Balancer

C# .NET Library to provide balancing feature to registered computation nodes.

`SimulatorBalancerLibrary/*` .NET DLL library to balance simulation requests going from MATLAB to remote computation nodes, based on their previous registration on ComputationNodes/W#3orkers.

compilation

The SimulatorBalancer is compiled as DLL, which is then loaded by the Identification Algorithm.

Web Simulator

C# ASP.NET with ServiceStack RESTfull web services holding the simulation screen definition and simulation screen viewer.

Computation Node

from https://github.com/TomasKulhanek/Physio.FmiRestService

- `FmiBatchWrapper/*` console application for performing FMI simulation, parameter sweep, etc. It is used as the BOINC client application to perform parameter sweep in obtained parameters
  `Program.cs` main program with following arguments:

```
FMIBatchWrapper [resultfilename] [modelname] [paramnames]
                [paramvalues] [paramsweppnames]
                [parametersweepstartvalues]
                [parametersweepstopvalues] [parametersweepsteps]
                [variabletoreturn] [starttime] [stoptime]
                [steps] [stepstoreturn(<=steps)]
```

- `FmiRestServiceWrapper/*` local server giving RESTful web service for performing simulation via HTTP. The application uses ServiceStack for building REST api via HTTP. The `Program.cs` is main program and detects all FMU files in working directory. These FMU's are presented and available to simulation via HTTP using URL: http://localhost:port/simulation/[fmufilename]/
- `BatchWrapperTest/*` unit test form FmiBatchWrapper
- `TestFmiRestService/*` unit test for FmiRestServiceWrapper

Known Issues

An attempt was made to load a program with an incorrect format.

```
2016-02-18 11:15:49.8855 ERROR exception during identification The type initializer for '
   at RestMasterService.WebApp.IdentifyStateTicker.IdentifyComputation() in c:\Users\toma
2016-02-18 11:15:49.8855 ERROR innerexception:The type initializer for 'MathWorks.MATLAB.
2016-02-18 11:15:49.8855 ERROR innerexception:The type initializer for 'MathWorks.MATLAB.
2016-02-18 11:15:49.8855 ERROR innerexception:An attempt was made to load a program with
at MathWorks.MATLAB.NET.Arrays.MWArray..cctor()
```

This might be caused by 64-bit DLL loaded by 32-bit DLL. Reinstalling the MCR 8.1 32-bit may solve the issue. Also compile the IdentificationAlgorithm, RestMasterServer, SimulatorBalancerLibrary for AnyCPU or x86.