Swumsuit Manual

2005/12/19
for Swumsuit version:2.2.0

1 Outline

Swumsuit is a software in which the swimming human simulation model SWUM proposed by Motomu Nakashima et al [1] is implemented. As input, body geometry, joint motion and analysis settings are given and they are passed into the analysis engine part. The analysis engine estimates the fluid force acting on the human body from the body geometry and joint motion, solves the equation of motion for the human body as a rigid body, and compute the absolute motion of the human body. The analysis engine also outputs many quantities from the computation, such as swimming speed, power efficiency, thrust, joint torque.

By using Swumsuit, the user can perform all tasks in the simulation, such as, editing input data, starting analysis, and displaying results of many quantities by graph and animation, with GUI operation without paying attention to inside of the simulation program.

Due to this easiness of operation, Swumsuit provides for everyone a pleasant environment to simulate the dynamics of swimming, which have been thought to be very difficult with respect to human motion and formulation of the fluid force.

Swumsuit is a Free Software distributed under GPL (GNU General Public License).

2 Location of Distribution

You can get Swumsuit at the website http://www.swum.org/swumsuit/.

3 Required Environment

Swumsuit runs on Windows 2000 Professional, Windows XP or higher, and Linux. It does NOT run on Windows 95, 98, Me. For Linux, ActiveTcl (http://www.activestate.com/Products/ActiveTcl/) and BLT package (http://sourceforge.net/projects/blt/) must be necessary.

You also needs ImageMagick (http://www.imagemagick.net/) and Ghostscript (http://www.cs.wisc.edu/~ghost/) to output animation results as BMP, GIF, JPEG and MPEG formats.

4 Installation and How to Startup

The installation of Swumsuit is very easy, however, you have to do it manually, not automatically with self extracting installer program.

1. Extract the downloaded swumsuitX_X_X.zip with some extracting software.
2. Copy the folder "Swumsuit" into your desired location. Please do NOT locate the folder on a network drive.

   This is basically all you have to do for installation.
3. To startup on Windows, double-click the file "swumsuit_en.exe", which is represented by an icon of "SWUM". The file "swumsuit_jp.exe" is the Japanese version. If you feel troublesome to open the Swumsuit folder every time, making a shortcut to the EXE file on the desktop might be help.

   To startup on Linux, enter swumsuit_en.tcl on Xterm at the Swumsuit folder. It will NOT run if the wish command is not the one of ActiveTcl. To check this, enter "which wish" and it is ok if the return message is /usr/local/ActiveTcl/bin/wish, or similar. If the message is not something like that, please check your "path" configuration.

It might be troublesome to move directory every time on Linux. If so, making a shell-script as below and copying it as /usr/bin/swumsuit_en will be help.

```
#!/bin/sh
cd /usr/local/lib/Swumsuit
wish swumsuit_en.tcl
```

Do not forget that you have to set the file /usr/bin/swumsuit_en executable (chmod 755 swumsuit_en).

5 Operation

5.1 Main Window

The main window is the window which you see first after the startup.

5.1.1 Project Folder Tab

In Swumsuit, a data set of three input files, that is, body geometry, joint motion and analysis settings, and many output data files (and comment file, optionally) is called a "Project". This set is located in a folder, which is called "Project folder". That is, the project folder includes all the conditions and the results of the analysis.

At the project folder tab, the operation related with the project folder is conducted.

Create Use this when you create a new project folder. In this case, loading separately data files of body geometry, joint motion, analysis settings are necessary. Actually, this function might not be used often.

Open Open an existing project folder. You will be warned if there is not even one data file among the body geometry, joint motion and analysis settings.

The names of 10 folders opened so far are listed.

Save As Use this when you save a project folder as another name after opening the project folder. At this function, only three input data files are copied and saved in the project folder of another name. The output data are NOT copied. This function will be typically used in the case of analysis with changed parameters. That is, first open an existing folder, next change the parameters, and save it as another name using this function.

You will be asked whether the comment is copied or not, when the project folder has its comment and comment file exists.

Info Display the location and comment of the project folder. You also can edit the comment and save it.

Note that the location of the project folder is displayed in the window title bar of the main window.

5.1.2 Input Tab

Edit Body Geometry Invoke the edit body geometry window. Please see 5.2 for details.

Edit Joint Motion Invoke the edit joint motion window. Please see 5.3 for details.

Load Body Geometry Load body geometry file. Although body geometry file is always saved as "body_geometry.dat" in the project folder, any file with a name "∼.dat" can be loaded with this function. For example, you can store body geometry data of averaged male and female as geometry_male.dat and geometry_female.dat, respectively, and load whichever you need for analysis. The data file is automatically renamed as body_geometry.dat when it is located in the project folder.

Load Joint Motion Load joint motion file. Although joint motion file is always saved as "joint_motion.dat" in the project folder, any file with a name "∼.dat" can be loaded with this function. For example, you can store joint motion data of crawl and breast stroke as crawl.dat and breast.dat, respectively, and load whichever you need for analysis. The data file is automatically renamed as joint_motion.dat when it is located in the project folder.

5.1.3 Analysis Tab

Start Analysis Start analysis. The analysis engine runs on a command prompt window on Windows, or Xterm on Linux. The analysis takes generally a few to tens minutes, although the calculation time depends on the analysis condition. During the analysis, several quantities are displayed, such as, cycle, direction, x, y, stroke length, stroke length deviation. These respectively are stroke cycle, direction in the horizontal plane (x-y plane), x and y coordinates of the mass center, nondimensional stroke length, and a ratio between two values at the present and previous cycle of the nondimensional stroke length, which can be a criterion whether the calculation reaches a steady condition or not.

Edit Analisys Settings In the edit analysis settings, number of time step, the fluid force coefficients and so on can be changed. Please refer section 7.1 for the first seven lines of "Solve" or "Given".

At the "Initial condition", the initial position, direction, velocity and angular velocity can be changed. And at the "Initial direction in x-y plane", you can correct the direction of propulsion. That is, in the case of asymmetrical motion, such as the crawl swimming, the human body propels obliquely even if the initial direction faces toward -x direction. In this case, check the calculation results of "direction" at the steady state, and if the value is 34 degree, you can obtain the results of straight swimming toward -x direction by substituting -34 into the "Initial direction in x-y plane".

At the "Output settings", you can choose which data are outputted. Outputting all the calculation results for all cycles results in heavy load to the system and increase of calculation time. You can save the disk space and time if you do not output unnecessary data.

Load Analysis Settings Load analysis settings file. Although analysis settings file is always saved as "analysis_settings.dat" in the project folder, any file with a name "∼.dat" can be loaded with this function. The data file is automatically renamed as analysis_settings.dat when it is located in the project folder.

5.1.4 Output Tab

Animation Invoke animation window. Please see 5.5 for details.

Graph Invoke graph window. Please see 5.6 for details.

5.1.5 Other Tab

Preferences Configure preferences. At the present version, you can select the OS of the analysis engine. Default is "Auto detect". That is, the present OS, on which Swumsuit is running, is automatically judged as the OS for analysis engine. However, in some case, you might would like to share files between Windows and Linux through network, configure the analysis condition on Windows, and run the analysis engine on Linux. In this case, release automatic judgement, and select the OS you would like. Actually, the execute file of the analysis engine is copied into the project folder for each time of analysis. The file names are SWUM_ENGINE_WINDOWS for Windows and SWUM_ENGINE_LINUX for Linux, respectively. Therefore, if the OS of the analysis engine is set as Linux on Windows, SWUM_ENGINE_LINUX is copied into the project folder when the analysis starts. (Of course, the execute file for Linux does not run on Windows.) And if you login to the Linux box with some terminal software, move into the project folder, and execute SWUM_ENGINE_LINUX, then the analysis will start normally on Linux.

Manual Display how to obtain the manual.

About Display version information and so on.

Exit Exit the software.

5.2 Edit Body Geometry Window

You can edit the body geometry on this window. If you click "Figure", the modeled human body is displayed in three-dimensional form. On the figure window, by dragging up and down, right and left with keeping left clicking, you can rotate the human body about horizontal and vertical axes in the screen plane. By dragging up and down with keeping right clicking, you can rotate it about normal axis to the screen plane.

You can change the size and density ratio to the water on this window. When you change the value in an entry, it will be reflected on the figure by clicking "Apply".

After changing values, click "Save" and close the window.

5.3 Edit Joint Motion Window

You can edit the joint motion on this window. Please load some project first, then invoke this window. The number of frame for one cycle is displayed at the upper left. At the right side, plural lines, whose each line consists of rotated body segment, rotating axis and angles of all frames, are displayed.

In SWUM, the joint motions are represented as rotation of each body segment about joint. The axes of rotations are one of the body base coordinate xb, yb and zb. The rotation angle is not relative but absolute. That is, even if you rotate the thigh for certain angle, the rotation does not affect the shank. In order to rotate the shank for same angle, you have to give same rotation angle for the shank. The rotation is IN ORDER which is displayed in the right side of the window. Therefore, in the case of rotation for a certain body segment, the results becomes DIFFERENT between the rotations of xb-yb and of yb-xb.

At this window, you can copy, cut, paste of each rotation, and also create a new rotation. In order to select a rotation, click line of the rotation in the right side. With keeping pressing shift key, you can select the range of lines. With keeping pressing ctrl key, you can select multiple lines. By "Paste", the copied line(s) is(are) pasted under the selected line.

At "Animation", the joint motion is displayed with three-dimensional animation. On this animation window, by dragging up and down, right and left with keeping left clicking, you can rotate the human body about horizontal and vertical axes in the screen plane. By dragging up and down with keeping right clicking, you can rotate it about normal axis to the screen plane. You can also change the displaying speed and can move to an arbitrary frame with scale after pausing.

On this window, you can not edit the body segment to be rotated, the rotation axis, and each value of the rotating angle, although you can change the order of the rotations and can copy them. In order to edit them, you have to double click the line to be edited or click "Edit motion" with selecting the line, and invoke "Edit each joint motion" window explained in the next section.

5.4 Edit Each Motion Window

On this window, you can edit body segment, rotation axis, and angle at each frame for each rotation. The values of angles at all frames are displayed on the left side in numerals, and on the right side with a graph. Note that, in SWUM, gaps between frames are interpolated with Spline function as shown in the graph on the window. By clicking "Apply" after changing numerals on the left side, the graph on the right side will be also changed. On the lower right side, you can perform operation for all frames. You can move in X and Y directions, magnify, and invert all the angles.

This window works together with the animation which is invoked at the edit joint motion window. That is, by pausing the animation at a frame, background color of the numeral entry for the frame on the left side is changed into yellow. And a large yellow point appears on the graph, too. Therefore, if you find a joint angle to be changed at a frame watching the animation, you can easily find the corresponding angle of the frame.

5.5 Animation Window

At this window, you can see three-dimensional animation of the analysis results. On this window, by dragging up and down, right and left with keeping left clicking, you can rotate the human body about horizontal and vertical axes in the screen plane. By dragging up and down with keeping right clicking, you can rotate it about normal axis to the screen plane. You can also change the display speed and can move to an arbitrary frame with scale after pausing.

The red lines from each part of the body represent the direction and magnitude of the fluid force. The length of the lines also can be changed by clicking the arrow mark at the side of “Force”. The propulsive distance in one cycle is divided into two kinds of areas with different depth of colors on the water surface.

In “Output Settings” of “Edit Analysis Settings”, if you choose “All cycles” for animation, you can select whether all cycles are displayed or only the last cycle is displayed, by clicking “All” or “Last” on the lower right side of the window. In the case of ‘All”, the animation stops for a moment at each end of cycle. This is not a bug but the normal behavior. In the case of “Last”, the last cycle is animated without the stop.

At the lower left “Rotation angle” part, the rotation angle of the animation can be inputted with numerals. Please click “Apply” after inputting.

By clicking “Output”, you can output the animation results as series of image files in EPS, BMP, GIF JPEG format, or as a movie file in MPEG format. The files are outputted into “Output_images” folder in the project folder. You can select image size and whether all cycles, the last cycle, or this moment is outputted. In the case of outputting all cycles as a MPEG movie file, sometimes it might fail. In that case, please set the image size as 1/2 or 1/4. You have to wait for much time for this process.

5.6 Graph Window

The Graph window is invoked by clicking firstly “Graph” at the “Output” tab in the main window, and selecting quantities to be displayed. The graph title is shown at the upper part of the window. You can dimenionalize/nondimensinalize the graph by clicking “dimension”. You can configure graph range by clicking “Range”. If you leave the range as blank, the graph range is automatically determined.

If you bring the mouse pointer close to line of the graph, the values of abscissa and ordinate at the nearest data point are displayed, and you can easily read numeral values from the graph.

The “Output” part supports many kinds of format. For Window, you can output into formats of Clipboard, Windows meta file (WMF), Extended meta file (EMF), and EPS. For Linux, EPS format only.

6 Optimization

6.1 Overview

On the version 1.4.0 or later, calculation of optimization can be performed. As the optimizing method, the classical Downhill Simplex method, which is well-known as an nonlinear optimizing method, has been implemented so far. With respect to the flow of optimization, the normal flow of analysis is completely covered by the optimzation loop as below:

1. Set the initial values of design variables of the optimization.

2. Create input dafa files (body geometry joint motion, and analysis settings dafa files) from the values of design varialbles.

3. Perform the analysis engine.

4. Compute the value of objective function from the output data files.

5. Compute new value of the design variables from the objective function, based on the optimizing algorithm.

6. Go back to 2.

For the above procedures of 1, 2 and 4, the user have to create three scripts described later.

6.2 Optimization Settings Window

On the optimization settings window, which is invoked by clicking 'Edit Analysis Settings' and 'Optimization settings', you can configure options with respect to the optimization. At the line of 'Display calculation window', you can set whether the calculation window for the analysis engine is displayed or not during optimizing calculation. It might be better to set 'yes' at a test run with referring the results, and 'no' at the long, full-scale calculation.

6.3 Scripts For Optimization

The user have to describe below three scripts for the optimization. The scripts have to be written in the format of Tcl/Tk. By clicking 'Edit Analysis Settings' and 'Edit scripts for optimization', editing window for them can be invoked.

6.3.1 Script to Set Initial Values of Design Parameters (opt_initial_values.tcl)

In the optimization, the design variables are stored in an array 'xopt' (xopt(1), xopt(2) ...). The initial values of this array is set in the present script. The number of array elements must agree with that of 'number of design parameters' at the 'Optimization settings'.

Note that the sample file is automatically loaded when this script is firstly edited in a project folder. The details of the format will be found in the sample file. You can edit directly the script by your favorite editor software, not on Swumsuit, since the script is saved as a file 'opt_initial_values.tcl' in the project folder.

6.3.2 Script to Set Design Parameters (opt_design_parameters.tcl)

An the present script, the design variable xopt is transformed into values in the input data files. For this purpose, a special command 'ReplaceInputData' is prepared. By this command, you can configure which input data file, which line, and which column are replaced into which data of the design parameters (xopt).

Note that the sample file is automatically loaded when this script is firstly edited in a project folder. The details of the format will be found in the sample file. You can edit directly the script by your favorite editor software, not on Swumsuit, since the script is saved as a file 'opt_design_parameters.tcl' in the project folder.

6.3.3 Script to Set Objective Function (opt_objective_function.tcl)

In the optimization, a variable 'yopt' is used as the objective function. This script has to be described so that the value of yopt is computed from the output data files. For this purpose, a special command 'GetOutputData' is prepared. By this command, you can configure which output data file, which line, and which column are retrieved. You have to describe the script so that the value of the objective function yopt is finally given using retrieved data. Since yopt is *maximized* in the optimization, you have to write the script as 'greater is better'.

Note that the sample file is automatically loaded when this script is firstly edited in a project folder. The details of the format will be found in the sample file. You can edit directly the script by your favorite editor software, not on Swumsuit, since the script is saved as a file 'opt_objective_function.tcl' in the project folder.

6.4 Optimization Log Window

This window is invoked by clicking the "Optimization log" button in the "Output" tab. On this window, you can view the log of the optimization. In the window, "iteration" is the number of iteration, "loop" is the number of whole iteration loop, and the values of the array xopt and the objective function yopt are displayed. These contents are stored in the project folder as a file "optimization_log.dat".

By clicking the "Abort" button, you can abort the analysis.

7 Other Advanced Functions

7.1 Function To Give Forcedly The Absolute Motion

On the version 1.4.0 or later, you can give the absolute motion of the whole swimmer's body without solving the equations of motion. This function is convenient in the case when, for example, you input the absolute motion obtained by a motion capture system and would like to compute the fluid force only. The setting is performed by choosing the various cases by the seven lines on the screen which appears after choosing "Edit Analysis Settings" and "Calculation Settings". If you set "Center of mass and principal axes of inertia" as "Given", The center of mass and the principal axes of inertia are respectively fixed to the lower tip of the lower waist segment and to the body coordinate x_b, y_b, z_b. For the each value of velocity and angular velocity at the second to seventh line, you can set whether the equation of motion in each direction is solved or not. If you set it as "Given", you have to prepare the data for one cycle as a text file with a special name. The names are in same order with the screen, and respectively are input_vgx.dat, input_vgy.dat, input_vgz.dat, input_ome1.dat, input_ome2.dat, input_ome3.dat. With respect to their format, they have to have same number of lines as "number of time steps for one cycle", and have only one column of velocity/angular velocity value in each line. For example, if the "number of time steps for one cycle" is four, The file content becomes such as:

```
0.0
0.10
0.30
0.15
```

and the file name must be as above. Since you can not create the data file on Swumsuit, you have to use other software to do it.

7.2 Penetration Judging Function

On the version 2.1.0 or later, you can obtain the results of judgement whether each part of the body is penetrated to the other or not. Using this function, you can avoid unreasonable penetrating motion in the case of motion optimization by adding this information as a penalty to the objective function. The setting of this function is performed on the screen which appears after choosing "Edit Analysis Settings" and "Penetration judging settings". At the first line on the screen, you can set whether the penetration judging is performed or not. At the second and later lines, you can set combination of the judgement, that is, judgement whether which part is penetrated to which other part. This judgement is performed by judgeing whether distance between a tiny quadrangle, into which the surface of the truncated elliptic cone is divided for calculation of the buoyancy, and another quadrangle becomes under a constant value or not. If the distance is under the constant value, combination of these tiny quadrangles is counted, and finally the number of the counted combination is outputted. This judgement is performed at the first cycle of analysis only. And since the judgement increases considerably the computation time, it may be better to set the number of combination of the body parts minimum. The results of judgement are outputted into a file named 'penetration.dat' under Output_data in the project folder. With respect to its format, each line corresponds to each time step. Therefore, the number of lines in the data file is 'number of time steps for one cycle'. The first column is total number for all body part combinations. The second and later columns correspond respectively to the values of ten combinations in same order as the configure screen. If the judgement is not performed for a combination, '-1' is outputted.

8 Data Format

You usually do not have to care about data format of input and output data. However, sometimes you would like to edit data directly by some edit software, or would like to extract certain data which are not displayed by displaying function of Swumsuit. Fot those purpose, data format for each data file is respectively described in the following.

8.1 Body geometry data file (body_geometry.dat)

The format of body geometry data file "body_geometry.dat" is almost same as screen of the edit body geometry window, and is as below. The number of lines is 30. The quantities are nondimensionalized with height unless specifying.

(root depth of body segment 1) (root width) (tip depth) (tip width) (length) (density)
(root depth of body segment 2) (root width) (tip depth) (tip width) (length) (density)
:
(root depth of body segment 21) (root width) (tip depth) (tip width) (length) (density)
(distance between shoulder joint and upper arm's root in yb direction)
(distance between shoulder joint and upper arm's root in zb direction)
(distance between neck's tip and head's root in xb direction)
(distance between lower hip's tip and hip joint in yb direction)
(distance between lower hip's tip and hip joint in zb direction)
(distance between shank's tip and foot joint in zb direction)
(Rotating angle of upper and lower hip parts [rad])
(actual height [m])
(actual weight [kg])

The numbers for body segment, that is, 1 to 21, respectively correspond to lower waist, upper waist, lower breast, upper breast, shoulder, neck, head, upper hip, lower hip, right thigh, left thigh, right shank, left shank, right foot, left foot, right upper arm, left upper arm, right forearm, left forearm, right hand and left hand.

8.2 Joint motion data file (joint_motion.dat)

The format of joint motion data file "joint_motion.dat" is as below.

(number of frames in one cycle (denoted by N))
(rotating body segment No.) (rotating axis No.)
(rotating angle of frame 1)
(rotating angle of frame 2)
:
(rotating angle of frame N)
(next rotating body segment No.) (rotating axis No.)
(rotating angle of frame 1)
(rotating angle of frame 2)
:

(rotating angle of frame N)
:
:
(rotating angle of frame N for last rotation)
0 0

"0 0" at the last line is to notify the analysis engine that the coming line is the last line. The rotating body segment No. is same as body geometry data file. The numbers of rotating axis respectively correspond to xb axis: 1, yb axis: 2, zb axis: 3, xb axis (right shoulder elevation): 4, yb axis (right shoulder elevation): 5, zb axis (right shoulder elevation): 6, xb axis (left shoulder elevation): 7, yb axis (left shoulder elevation): 8, zb axis (left shoulder elevation): 9. Note that "right/left shoulder elevation" is to express shoulder blade's motion. For this purpose, shoulder joint point itself can be rotated about midpoint between both shoulder joints.

Each rotation is performed in order described in this data file. And Each rotation rotates the corresponding body segment only. That is, if you set the rotation of upper arm (sholder joint), that rotation does not affect the hand and forearm. You have to set same rotation for the hand and forearm if you would like to rotate them.

8.3 Analysis settings data file (analysis_settings.dat)

The format of Analysis settings data file "analysis_settings.dat" is a sort of "free format" as below.

(name of parameter to be defined)=
(value of the parameter)

That is, the value of the parameter is described at the line next to that for the name of the paramter. The change in the order of the parameter and number of blank lines do not become any problems. In the case of parameter with multiple values, "value of the paramter" line becomes multiple lines and/or multiple columns.

8.4 Motion description data file for animation (motion.dat)

The format of motion description data file for animation "motion.dat" is most complicated and as below:

(number of time division for one cycle) (cycle No.) (total number of cycle)
(number of body segment)
(number of division for each body segment in longitudinal direction)
(averaged nondimensional stroke length for the cycle)
(averaged swimming direction for the cycle [deg])
(21 lines to describe position of each body segment at the first time step)
(21x(number of division for each body segment in longitudinal direction) lines to describe fluid force)
:
(21 lines to describe position of each body segment at the last time step)
(21x(number of division for each body segment in longitudinal direction) lines to describe fluid force)

The above example is for the case of one cycle. In the case of multiple cycles, "Cycle No." at the first line and the second column becomes the value of next cycle, and latter part is repeated. The 21 lines to describe position of each body segment at the sixth line above has 12 columns and the format is as below:

(x position at center of body segment 1's root) (y position) (z position) (continued below)
(x position at center of body segment 1's tip) (y position) (z position) (continued below)
(x component of body segment 1's ellipse axis 1) (y component) (z component) (continued below)
(x component of body segment 1's ellipse axis 2) (y component) (z component)

:
:
(x position at center of body segment 21's root) (y position) (z position) (continued below)
(x position at center of body segment 21's tip) (y position) (z position) (continued below)
(x component of body segment 21's ellipse axis 1) (y component) (z component) (continued below)
(x component of body segment 21's ellipse axis 2) (y component) (z component)

The format of the lines to describe fluid force is as below for one body segment. The number of lines is (number of division for each body segment in longitudinal direction) and the number of columns is 6.

(x position of start point of the first fluid force vector in longitudinal axis division) (continued below)
(y position of start point of the first fluid force vector) (continued below)
(y position of start point of the first fluid force vector) (continued below)
(x component of fluid force vector) (y component of fluid force vector) (continued below)
(z component of fluid force vector)
:
(x position of start point of the last fluid force vector in longitudinal axis division) (continued below)
(y position of start point of the last fluid force vector) (continued below)
(y position of start point of the last fluid force vector) (continued below)
(x component of fluid force vector) (y component of fluid force vector) (continued below)
(z component of fluid force vector)

The above lines are repeated for number of body segments (21).

8.5 Graph data file

All graph data files are located at the "Output_data" folder in the project folder. The format of the graph data file is all the same among all graph data files, and it consists of 9 lines header part and the following data description part as below.

(graph title)
(abscissa title)
(ordinate title)
(number of lines in the graph)
(line 1 title) (line 2 title) ...
(dimensionalizing coefficient for abscissa)
(dimensionalizing coefficient for ordinate)
(abscissa unit)
(ordinate unit)
(abscissa value 1) (ordinate line 1 value 1) (ordinate line 2 value 1)
(abscissa value 2) (ordinate line 1 value 2) (ordinate line 2 value 2)
:
(abscissa last value) (ordinate line 1 last value) (ordinate line 2 last value)

The fourth line is the number of lines in one graph when multiple lines are drawn in the graph. If this value is 1, the fifth line becomes blank line of "#", and lines after tenth line have only two columns.

9 Developping Environment

Below environments and softwares are used for developing this software. We greatly appreciate the author of these softwares, especially noncommercial softwares.

Windows

- Windows XP Professional
- ActiveTcl 8.4.6 (http://www.activestate.com/Products/ActiveTcl/)
- BLT 2.4z (http://sourceforge.net/projects/blt/)
- Togl 1.6 (http://togl.sourceforge.net/)
- freeWrapPLUS 6.0 (http://freewrap.sourceforge.net/) (The executable file "wish_windows.exe" in the Swumsuit package is created by merely renaming "freewrapPLUS.exe" in the package.)
- freeWrap 5.61 Japanese version (http://reddog.s35.xrea.com/wiki/index.php)
- Intel Visual Fortran Compiler 8.1 (http://www.intel.com/software/products/compilers/fwin/)
- SLATEC numerical calculation library (http://www.netlib.org/)

<u>Linux</u>

- Vine Linux 2.6r1 (http://www.vinelinux.org/)
- ActiveTcl 8.4.6 (http://www.activestate.com/Products/ActiveTcl/)
- BLT 2.4z (http://sourceforge.net/projects/blt/)
- Togl 1.6 (http://togl.sourceforge.net/)
- g77 0.5.24 (http://www.gnu.org/software/fortran/fortran.html)
- SLATEC numerical calculation library (http://www.netlib.org/)

10 Contact

Please send any quastions, requests, bug reports and opinions to swum-admin_at_swum.org (please change _at_ into @). Any information is welcomed.

References

[1] Motomu Nakashima, Yasufumi Miura and Ken Satou, Swimming Human Model SWUM to Analyze Swimming Dynanical Problems, The Engineering of Sport 5 (Proceedings of the fifth international conference in engineering of sport), Vol.1, 594-600 (2004).