Phragmoplast Simulator User Guide

Description:

This application simulates microtubule (MT) dynamics within the phragmoplast of a plant cell. Various parameters that control the simulation, the microtubule dynamics, and microtubule nucleation can be used. Table 1 describes the parameters used in the simulation.

The simulator can be used in two ways: via the Graphical User Interface (GUI) or via command-line operation. Both methods are described below. The GUI allows for automatic data processing and analysis. It produces images, plots, and turnover values for each simulation. The command-line interface only produces raw data outputs that must be manually analyzed.

Simulator Data Outputs:

During the simulation, various data files are produced and are located into the folder specified by the fname_prefix parameter.

Bitmap Image Files (.bma): Contains the relevant information to create an image file (time, size, and image data)

JPEG Image Files (.jpeg): Contains the image produced for a specified timepoint

Kymograph File (_kymograph.jpg): Contains the kymograph of the simulation showing the change of fluorescence over time

Luminosity File (_luminosity.txt): Contains the number of MT in each state, the total length of MT, the average length of MT, and the amount of relative tubulin available.

Initialization File (_InitFile.csv): Contains the information about the nucleation of the MT at the beginning of the simulation

Histogram Files (_histogram_tX.txt): Histogram of MT lengths at the specified time point X

Fraction Files (_Fractions.csv): List of length fractions of the MT in the simulation. Each line is a new time point and shows the number of MT that fall into each bin of the fractions

Lengths File (_LengthsFile.csv): Contains the length of every microtubule at each time point in the simulation

Tubulin Density File (_RelativeMTDensity.csv): Contains the relative tubulin density over time

Parameters:

Parameter File Name	GUI Name	Description
fname_prefix	FrameNamePrefix	The filename prefix
DistType	DistributionType	The distribution type (0=, 1=, 2=)
NoMature_mode	No Mature Mode	Allows microtubules to enter a mature state
Thickness	Thickness	Thickness of the phragmoplast in microns
Width	Width	Width of the phragmoplast in microns
dx	Dx	Size step in microns
N_MT	NumMT	Number of microtubules
Npixel_X	Npixel_X	Number of X pixels in images
Npixel_Y	Npixel_Y	Number of Y pixels in images
t_min	TMin	Minimum time of the simulation
t_max	TMax	Maximum time of the simulation
FRAP_t	FRAPTime	FRAP time
FRAP_x1	FRAPX1	FRAP X1 coordinate
FRAP_y1	FRAPY1	FRAP Y1 coordinate
FRAP_x2	FRAPX2	FRAP X2 coordinate
FRAP_y2	FRAPY2	FRAP Y2 coordinate
bin_N	numBins	Number of bins in the histogram
outputJPEG	OutputJPEG	1=output JPEGs, 0=do not output JPEGS
outputBMA	OutputBMA	1=output BMA files, 0=do not output BMA files
blurRadiusJPEG	BlurRadius	Image Blur Radius
init_type	InitType	Type of initialization: RND or FIXED
writeImageTime	NoFigureTime	Do not write the time on the figures
rnd_seed	RandomSeed	Random seed to initiate simulation with
SimIndex	SimIndex	The index of the simulation
r_polym	RatePolymerization	Rate of polymerization in micron/s
r_depolym	RateDePolymerization	Rate of depolymerization in micron/s
r_sg	RateShrink2Grow	Rate of transition from shrinking to growing
r_gs	RateGrow2Shrink	Rate of transition from growing to shrinking
r_pg	RatePause2Grow	Rate of transition from pause to growing
r_ps	RatePause2Shrink	Rate of transition from pause to shrinking

r_gp	RateGrow2Pause	Rate of transition from growth to pause
r_sp	RateShrink2Pause	Rate of transition from shrinking to pause
r_ps_CP	RatePause2ShrinkCP	Rate of transition from pause to shrinking in the defined cell plate region
r_ps_DZ	RatePause2ShrinkDZ	Rate of transition from pause to shrinking in the defined distal region
dens_MT	TubulinDensisty	Density of available tubulin per unit area
L0	InitialLength	Maximum initial length or fixed length at seeding
r_reseed	RateReseed	Rate of reseeding
frac_seed_middle_slope	MiddleSeedSlope	Slope of the seeds in the middle
frac_grow_out	FractionGrowOut	Fraction that grows out
frac_grow_in	FractionGrowIn	Fraction that grows in
frac_seed_distal	FractionSeedDistal	Fraction of seeds in the distal region
frac_seed_middle	FractionSeedMiddle	Fraction of seeds in the middle region
frac_seed_CP	FractionSeedCP	Fraction of seeds in the cell plate region
frac_treadmill	FractionTreadmill	Fraction of seeds that treadmill
theta_max	ThetaMax	Maximum angle of microtubules
CP_X_MAX	CellPlateXMAX	Maximum x value for seeds located in the cell plate region
DZ_X_MIN	DistalXMIN	Mimimum x value for distal region effect
DZ_SEED_MIN	DistalSeedMIN	Minimum x value for distal region seeds
grf_dt	ImageTimeStep	Time step between images
grf_max	ImageMaxLuminosity	Maximum image luminiosity (Normalized to 1)
kymograph_amp	KymographAmp	Kymograph luminosity amplitude
r_me_polym	RateMinusPolymerization	Rate of minus-end polymerization in micron/s
r_me_depolym	RateMinusDepolymerization	Rate of minus-end depolymerization in micron/s
r_me_gs	RateMinusGrow2Shrink	Rate of minus-end transition from growing to shrinking
r_me_sg	RateMinusShrink2Grow	Rate of minus-end transition from shrinking to growing

r_me_pg	RateMinusPause2Grow	Rate of minus-end transition from pause to growing
r_me_ps	RateMinusPause2Shrink	Rate of minus-end transition from pause to shrinking
r_me_gp	RateMinusGrow2Pause	Rate of minus-end transition from growing to pause
r_me_sp	RateMinusShrink2Pause	Rate of minus-end transition from shrinking to pause
TaxolCorr	TaxolCorrection	Taxol correction parameter
TdensCorr	DensityCorrection	Density correction parameter
SeedParameterA	SeedMean	The mean of the seeding distribution
SeedParameterB	SeedSpread	The standard deviation or spread of the seeding distribution
reseed_slope	ReseedSlope	The slope of the reseed rate curve
reseed_b	ReseedIntercept	The Y-Intercept of the reseed rate curve

Building the Code:

Prerequisite: GraphicsMagick must be installed to compile the code correctly. (http://www.graphicsmagick.org)

1. Modify the Makefile library directives to point to your installation of graphicsmagick
2. In the command line, type 'make', and press enter
3. If the code does not build correctly, verify that Graphicsmagick is linking correctly.

The build files and programs can be removed using the 'make clean' command.

Command Line Operation:

Before running a simulation, a parameter file must be created. See below for an example. After building the code, the following syntax will run a simulation:

./php_simulator_3s <parameter file>

To convert the image files (.bma) to JPEG images, use the following command:
./php_mkfig_3s -b <blur_radius> <BMA File Names>

GUI Operation:

The GUI can be launched via Matlab and will process the data automatically after a simulation is ran. There are various options for parameters and import/exporting data.

Importing Data:

Data can be imported from a raw data export folder or via a Matlab data file that was exported from the simulator. Parameter files can also be imported as .par or .txt files. Be sure to read the information about the parameters and view the example file below.

Exporting Data:

Data can be exported in multiple formats: as raw data files or as a Matlab (.mat) data file. The raw data contains images, plots, and the text data produced by the simulator. The Matlab file contains all the relevant data for the simulation and can be easily imported into Matlab or the simulator for further analysis.

Example Parameter File (.par)

Note: When creating a new parameter file, the order of the items must be the same as in this example.

Text following a '#' will be considered comments and are ignored in the parameter files.

ExamplePar.par

```
fname_prefix ./temp//DATA_1/Sim_1
DistType 0
NoMature_mode 1
Thickness 1.5
Width 5
dx 0.02
N_MT 1000
Npixel_X 228
Npixel_Y 768
t_min -300
t_max 300
FRAP_t 50
FRAP_x1 0.2
FRAP_y1 0.5
FRAP_x2 1.3
FRAP_y2 4.5
bin_N 25
outputJPEG 0
```

outputBMA 1
blurRadiusJPEG 1
init_type RND
writeImageTime 0
rnd_seed -1
SimIndex 1
r_polym 0.06
r_depolym 0.12
r_sg 0.059
r_gs 0.012
r_pg 0.084
r_ps 0.0115
r_gp 0.1141
r_sp 0.0154
r_ps_CP 0.013
r_ps_DZ 1
dens_MT 45.79
L0 0.805
r_reseed 1
frac_seed_middle_slope -1
frac_grow_out 0.05
frac_grow_in 0.95
frac_seed_distal 0
frac_seed_middle 0
frac_seed_CP 0
frac_treadmill 0
theta_max 20
CP_X_MAX 0.05
DZ_X_MIN 1.4
DZ_SEED_MIN 1.5
grf_dt 2
grf_max 1
kymograph_amp -0.8
r_me_polym 0.0327
r_me_depolym 0.046
r_me_gs 0.1
r_me_sg 0.039
r_me_pg 0.0065
r_me_ps 0.033
r_me_gp 0.056
r_me_sp 0.072
TaxolCorr 1
TdensCorr 1
SeedParameterA 1.1

SeedParameterB 0.35
reseed_slope -0.66
reseed_b 1