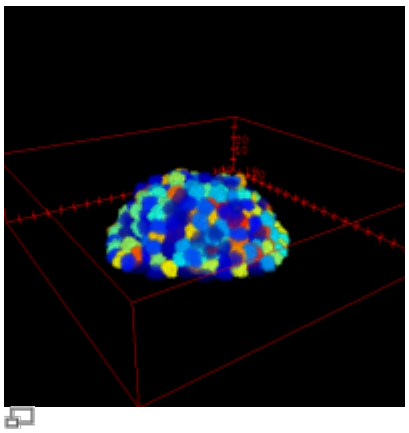
Cellular Potts models

Proliferation in three dimensions



Cell population grown from single initial cell

Introduction

This model show a CPM simulation of a growing cell population in 3D.

Model description

This model specifies `CellType` which has a `VolumeConstraint` and a `Proliferation` plugin. In the `Proliferation` plugin, the `Conditions` for a cell to divide are given. Here, each cell that has more than 90% of the target volume has a small probability to divide. Once a division has taken place, the `Equation` defined in the `Triggers` elements are triggered.

In this model, two `medium` cell types have been defined. One of these (called matrix) is used to represent a matrix with higher adhesivity. This is done by (1) defining the 'matrix' cell type as a `BoundaryCondition` of the -z boundary in the CPM and (2) providing lower contact energy for cell-matrix interaction than for cell-medium interactions.

The simulation is visualized using the `TiffPlotter` that saves TIFF image stacks that can be loaded by image analysis software such as Fiji and displayed using Fiji's 3D Viewer plugin.

Model

h Proliferation_3D.xml |h

```
extern>http://imc.zih.tu-dresden.de/morpheus/examples/CPM/Proliferation_3D.xml
```

In Morpheus GUI: `Examples → CPM → Proliferation_3D.xml`

Run and Tumble

Modeling cell movements as a Levy walk

Introduction

This example models a single cell that moves according to a Levy walk: a random walk with occassional occurrence of long straight walks.

Model description

The model defines a `CPM` cell that has two properties:

- A `PropertyVector` that gives the direction of movement and
- A `Property` that defines the time when this direction of movement is changed.

The change in direction is using a `VectorRule`. In this case, it specifies a new random direction for each of the 3 x,y,z coordinates separately: `move_dir = sin(angle), cos(angle), 0` where `angle = rand_uni(0, 2*pi)`.

This is calculated with an `Event`. Upon triggering, this sets the new direction and a waiting time until

the next change of direction. To model a superdiffusive Levy walk, this waiting time is chosen from an exponential distribution: `change_time = time + 20 * rand_gamma(0.5, 5)`

Finally, the cell is made to move in the chosen direction using `DirectedMotion` that takes the `PropertyVector` as input.

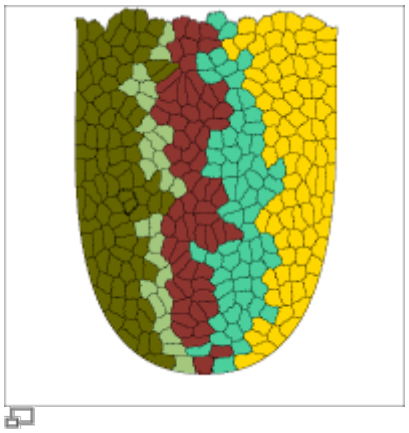
Model

h RunAndTumble.xml |h

```
extern>http://imc.zih.tu-dresden.de/morpheus/examples/CPM/RunAndTumble.xml
```

In Morpheus GUI: `Examples → CPM → RunAndTumble.xml`

Stem cells in the intestinal crypt



Asymmetric cell division and changing cell type

Introduction

This illustrative example shows the emergence of clonal populations from stem cells in an intestinal crypt. Stem cells in the bottom of the crypt divide asymmetrically and produce a population of transit amplifying (TA) cells. For each of the TA cells, the color indicates the stem cell is it derived from.

Model description

This model shows several new modeling features, available as of Morpheus 1.2.

Loading domain from image

The crypt-like domain is specified by loading an external 8-bit TIFF image file using `Lattice/Domain/Image`.

Asymmetric cell division

Stem cells divide asymmetrically using the new `ChildID` handles in the `Proliferation` plugin. This sets a user-defined symbol (here called `daughter`) to either 1 or 2. This symbol can then be used to distinguish both daughter cells and treat them differently. In this example, it used to set the stemness (`s`) of one daughter to 1 and the stemness of the other daughter cell to 0.

Conditionally changing cell types

When a cell looses its stemness `s`, it is moved to the TA cell type. This is done using the new `ChangeCellType` plugin.

Upon satisfyiug its `Condition`, `ChangeCellType` moves the cell to the specified new cell type. By default, all the properties of a cell that exist in both cell type context are maintained and unspecified ones are set to their default values. This default behavior can be overridden using `Triggers` that specify `Rules` stating how to deal with specific properties.

PopulationReporter

The new `PopulationReporter` allows the collection of statistical data about the cell population. Here, it is used to count the sizes of the various clonal populations. This number of reported into a `Global` and subsequently written to file and plotted using a `Logger`.

Model

h Crypt.xml |h

```
extern>http://imc.zih.tu-dresden.de/morpheus/examples/CPM/Crypt.xml
```

In Morpheus GUI: `Examples → CPM → Crypt.xml`