

Simulation of a University as a Dynamical System

UMBC REU Site: Interdisciplinary Program in High Performance Computing

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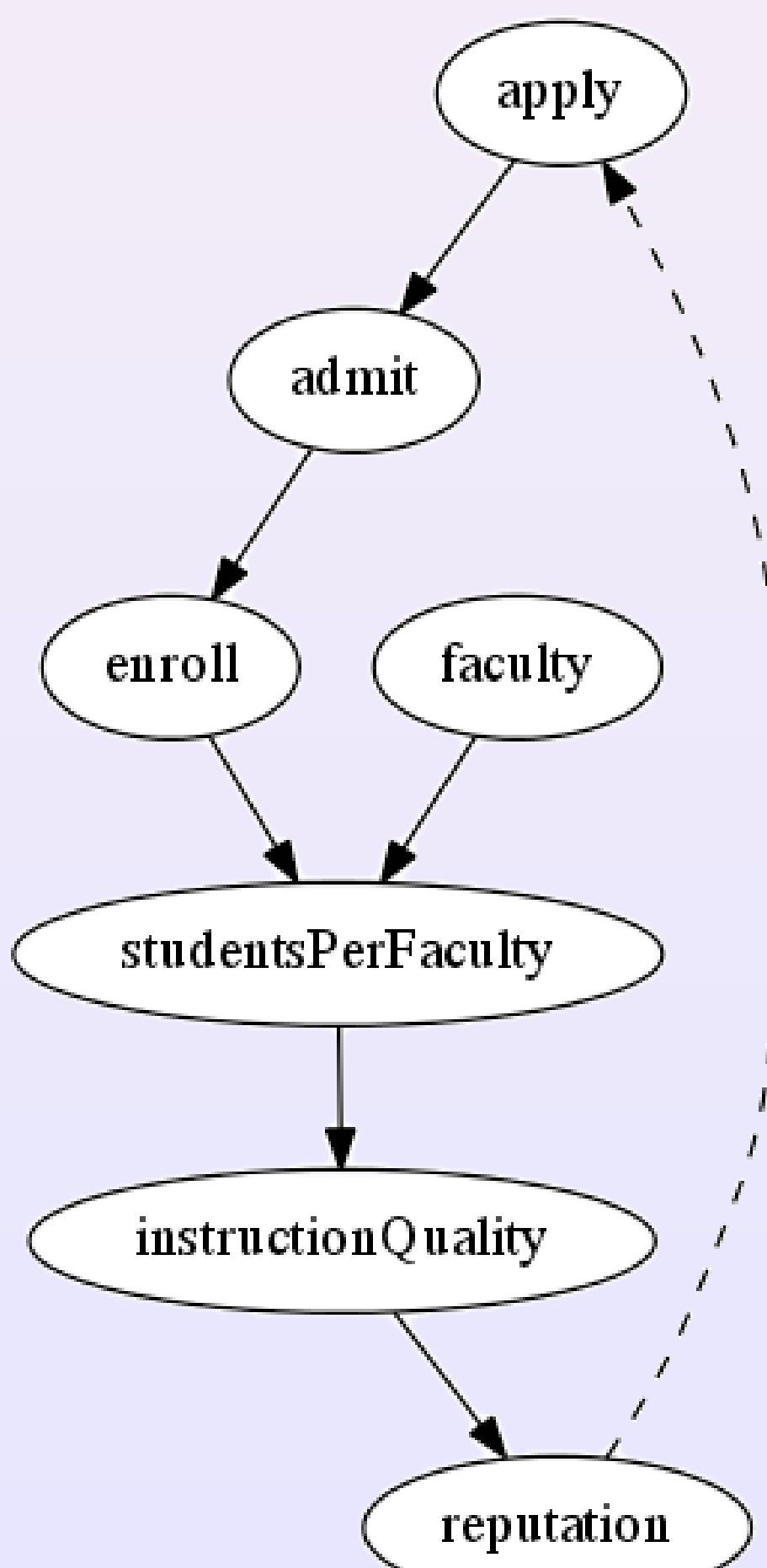
Problem Statement

Dynamical system models describe how complex physical and artificial systems change over time. One such system is a university. We model a university by defining variables and iterative equations to describe the complex relationships among them. We build the code in MATLAB to simulate this system for UMBC and use a graphical user interface (GUI) to visualize each variable as the university evolves. Our code models and produces visualizations of the state of the university as it changes over time as well as simulating “what-if” scenarios to aid in campus-wide discussion regarding growth.

Motivation

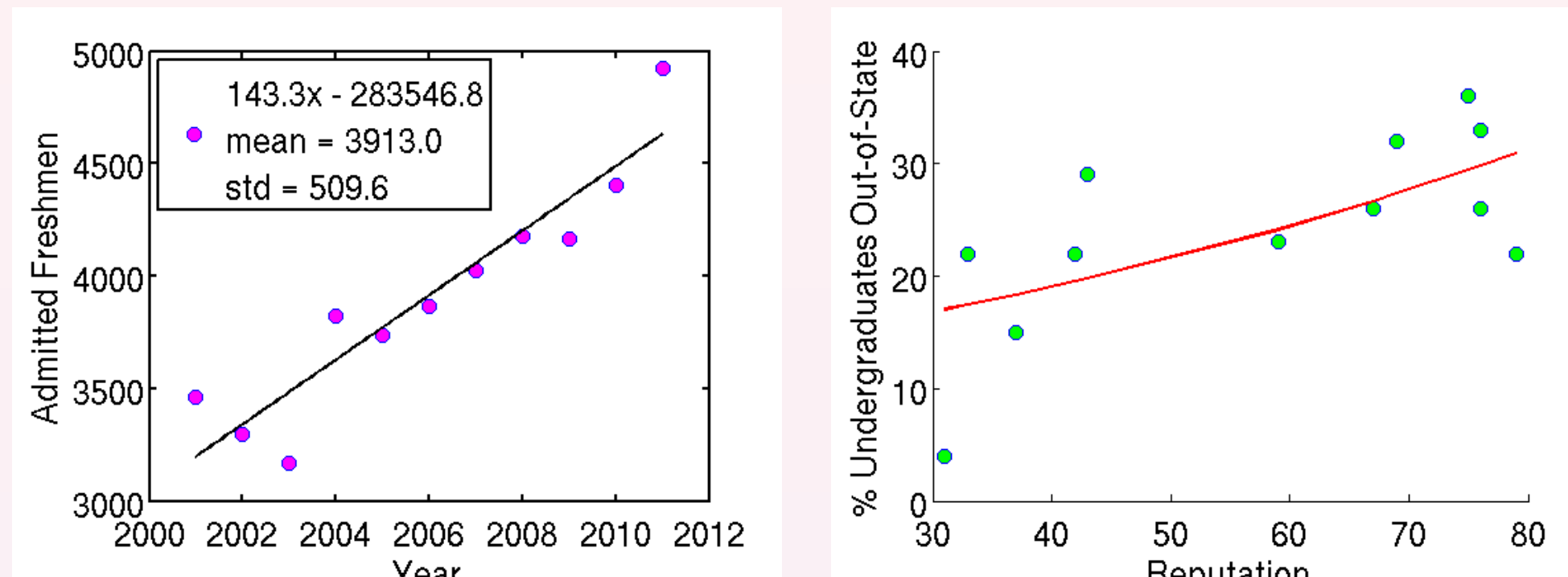
A **simple model** for a university can be visualized by a graphical representation of its characteristics:

- We define quantitative and qualitative characteristics of a university as **state variables**.
- Information from references like IPEDS and OIR suggest relationships among variables.
- We represent these relationships in **update functions** formulated for each variable.
- Update functions are evaluated with each iteration of the model and describe the state of the university at that time step.



Methods

◆ **Update functions for state variable are formed in several ways:**



- By analysis of past data as depicted by the plot on the left:

$$\text{admitFreshmen}_i = \mathcal{N}(3912, 509.6^2)$$

- Through examination of trends in relationships between variables as depicted by the plot on the right:

$$\text{studentsOutState}_i = 0.1155e^X \times Y$$

$$X = 0.01249 \times \text{reputation}_{i-1}$$

$$Y = \text{studentsUndergrad}_i$$

- As nearly constant but requiring an incorporation of stochasticity:

$$\text{facResearch}_i = \text{facResearch}_{i-1} + (X \times Z)$$

$$X = 2 \times \mathbb{1}(Y < 0.5) - 1$$

$$Y \sim \mathcal{U}(0, 1)$$

$$Z \sim \text{Poisson}(3)$$

◆ **Sample MATLAB code:**

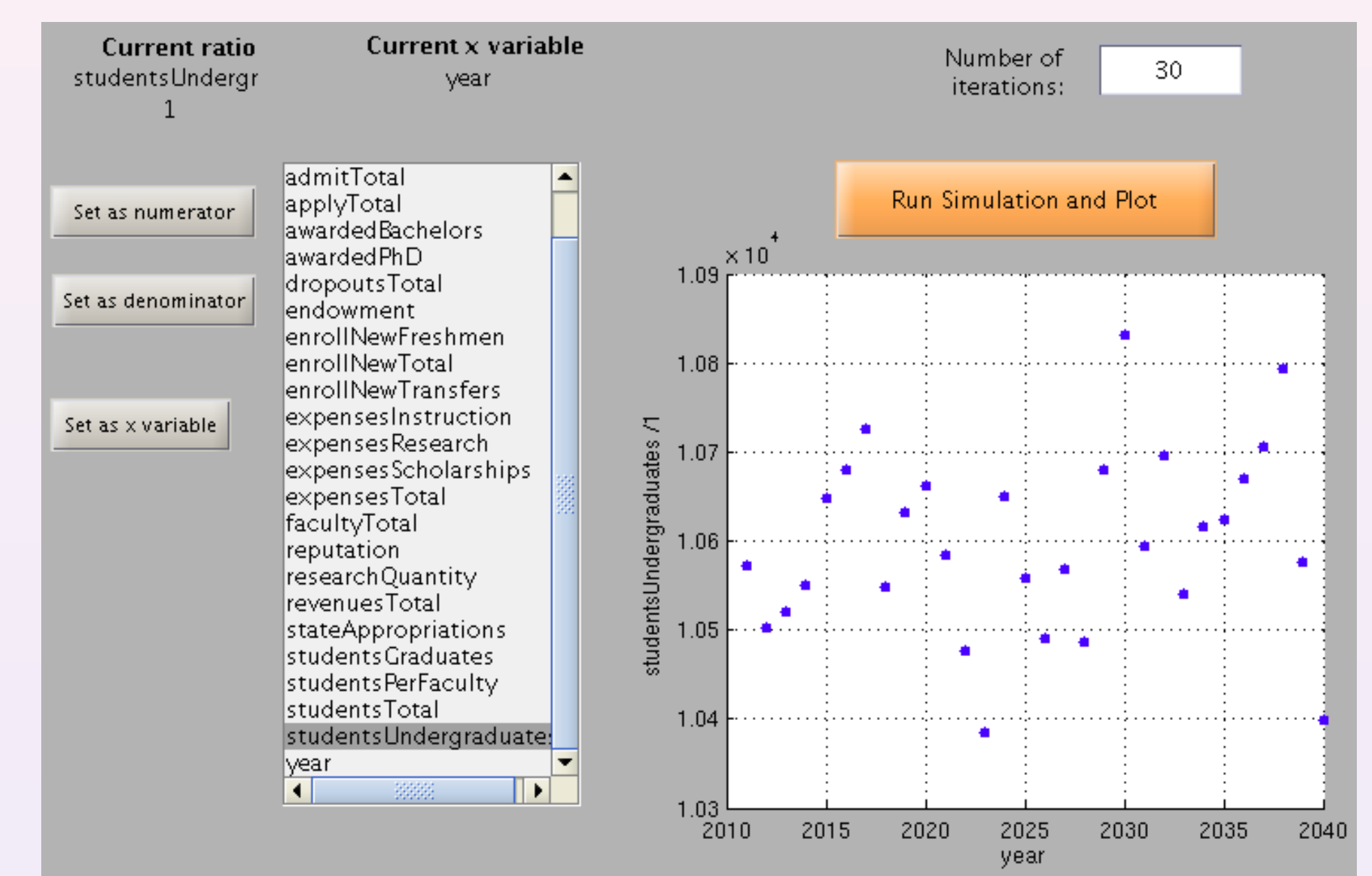
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function update_facResearch
    x = 2*(unifrnd(0,1)<0.5)-1;
    out = u{i-1}.facResearch ...
        + x*poissrnd(3);
end

function update_facTotal
    out = u{i}.facFullTime ...
        + u{i}.facPartTime;
end
  
```

Results & Conclusions

State variable values at each iteration can be viewed in our graphical user interface (GUI). The GUI displays the evolution of variable ratios and dependencies upon time or any user-selected state variable.



Before running the simulation, initial values of fields can be edited in the GUI in order to evaluate reactions of state variables to “what-if” scenarios.

Variable	Initial Value	Variable	Initial Value
5 awardedMasters	582	5 awardedMasters	582
6 awardedBachelors	1905	6 awardedBachelors	2905
7 awardedBachelors3rdYear	50	7 awardedBachelors3rdYear	50
8 awardedBachelors4thYear	600	8 awardedBachelors4thYear	1100
9 awardedBachelors5thYear	500	9 awardedBachelors5thYear	1000
10 awardedBachelors6thYear	875	10 awardedBachelors6thYear	875
11 awardedPhD	97	11 awardedPhD	97

Our final product is MATLAB code capable of generating simulations of a university in terms of 78 state variables. With our carefully developed equations, we see results consistent with past data and research-supported hypotheses.

References

- Office of Institutional Research: www.umbc.edu/oir/
- Integrated Postsecondary Education Data System (IPEDS): nces.ed.gov/ipeds/
- Full technical report: HPCF-2012-13 www.umbc.edu/hpcf > Publications

Acknowledgements:

- REU Site www.umbc.edu/hpcreu
- NSF, NSA, UMBC, HPCF, CIRC