3:15 pm: Jackson Lewis

A Modified BML Traffic Model

Cellular automata, particularly the Biham–Middleton–Levine (BML) model, have long served as computational tools for modeling traffic dynamics. I present a modified BML model to more accurately represent urban traffic by incorporating bidirectional vehicle movements along both north-south and east-west lanes within a structured grid-based city layout. The simulation investigates the effects of systematically varying vehicle density and the traffic-light cycle period at intersections, specifically highlighting their combined impact on traffic flow and congestion. Key performance metrics, such as jam probability and average vehicle velocity, are thoroughly analyzed. Notably, the simulation reveals a distinct jamming transition, where a critical vehicle density threshold triggers a rapid increase in congestion, significantly reducing traffic flow efficiency. These findings provide detailed insights into the dynamics of urban congestion and have practical implications for traffic management and urban infrastructure planning.

3:30 pm: Ray Zhang

Simulation of Simplified Settlers of Catan This project investigates the effectiveness of different strategic priorities in a simplified model of Settlers of Catan. Custom Python code was developed to model core game mechanics, including board generation, resource distribution, building logic, and win condition tracking. AI agents were assigned a city-prioritizing, a settlement-prioritizing, or a random strategy, and their performance was evaluated through three sets of experiments. Each set consisted of 10 independent simulations with 1000 games each $(10,000$ games per set). In Set 1, the city strategy was tested against a random-play agent and achieved an average win rate of $81.20\% \pm 0.27\%$, indicating both dominance and consistency. In Set 2, the settlement strategy was tested against the same random baseline and yielded a $64.13\% \pm 0.33\%$ win rate. Set 3 directly compared city-first and settlement-first agents, with the city strategy again prevailing at $68.63\% \pm 0.31\%$. Across all test conditions, the city-prioritizing strategy consistently outperformed settlement-focused play. These findings suggest that early investment in city upgrades confers a measurable and stable advantage under simplified conditions.

3:45 pm: Jorge Gherson

Molecular Dynamics Simulation of a Glass

We present a molecular dynamics simulation of a glass modeled by the Kob-Andersen Lennard-Jones 80:20 binary potential. The equations of motion for each particle are integrated through the velocity Verlet algorithm. We keep temperature constant by assigning all velocities periodically in time and from the corresponding Maxwell Boltzmann distribution. Our system consists of $N = 1000$ particles in a cubic box of length 9.4 with periodic boundary conditions. The particles are interacting through truncated and shifted 12-6 potentials with parameters as in [Kob and Andersen (1994)]. Thermostat performance is evaluated throughout the simulation's running time, and minimal energy drift is ensured by switching to the zero-momentum reference frame. The structural properties of the system are evaluated through radial distribution functions. Finally, the dynamical behavior is analyzed through the mean square displacement of each particle type.

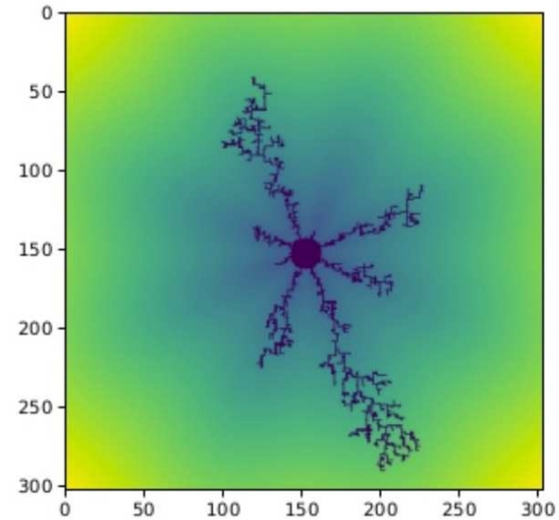
4:00 pm: Dylan Antonini

Epidemic Spread on Interconnected Lattices

Epidemic modeling provides insight into how diseases spread through populations and how network and population characteristics impact disease transmission. In this study, we simulate disease spread using the Susceptible-Infected-Susceptible (SIS) model on a spatial network composed of two coupled square lattices with inter-connections between nodes on opposing lattices. Inter-lattice links are formed under spatial proximity conditions and a coupling strength probability distribution.

We determine the disease's density as a function of time, and obtain the late time average, ρ_{eq}. The resulting ρ_{eq} as function of the infection rate of the disease, λ, shows the transition from $\rho_{\mathrm{eq}} = 0$ for $0 < \lambda < \lambda_{\mathrm{c}}$ to $\rho_{\mathrm{eq}} > 0$ and increasing for $\lambda > \lambda_{\mathrm{c}}$ and reaching a steady state plateau ρ_{s}. We find that the introduction of our coupling strength distribution causes increases in λ_{c} and ρ_{s}. For increasing recovery probability we find that λ_{c} increases and ρ_{s} decreases. With increasing recovery time λ_{c} decreases and ρ_{s} increases.

Computer Simulation Symposium



Bucknell University

April 30 & May 5, 2025

April 30 (ACWS 204)

3:00 pm: Geoffrey Gaines

Pumping Dynamics of Lymphatic Vessels

We study lymph and lymphangions using the model of Bertram et al. The system consists of three lymphangions of diameters D_1, D_2, D_3 and models the flow through each (Q_1, Q_2, Q_3). The dynamics is governed by the fluid dynamics due to pressure differences and muscle function. The Euler Method is applied to solve the resulting dynamics equations. Certain parameters, such as Q_1, Q_2, Q_3 and diameter of lymphangion (D_1, D_2, D_3), were studied as functions of time. The findings show, the one way flow of lymph, similar to electricity, that most functions are periodic in nature and or cyclic which agrees with the properties of hemodynamics. Certain parameters, namely resistance, displayed high or low states similar to that of a switch in signals and systems.

3:15 pm: Ethan Beachy

Modeling River Networks

By implementing extensions to the diffusion limited aggregation model specific to imitating river dynamics, the most probable paths a river network will follow over a given terrain can be simulated. In this model, a function with deterministic and random components was used to model natural basin terrain on a lattice. The change in elevation of the said terrain from one lattice to another, establishes anisotropy and step size variance within the Brownian motion of the walking particles representing rain water. Also, if the rain water walking particles encounter a local elevation minimum, the particles have a chance to transform into ground water and grow aggregate particles to the nearest existing aggregate particle. This model was able to successfully simulate river network generation corresponding to different basin terrain formations. Deeper valleys within the basin models lead to more narrow river networks. Lastly, the fractal dimension of the simulated river networks is negatively correlated to the range of the random offset parameter built into the terrain generation function.

3:30 pm: Kate Strong

Complex Dynamics of an Eco-epidemiological Predator-prey Model

Predator-prey models are essential tools for understanding population dynamics and ecological stability. Furthermore, studying the complex relationships within ecological systems is important for conservation and management efforts. The model we used for our simulation is an eco-epidemiological model, described in Saifuddin et al. (2016), that extends the classic Lotka-Volterra predator-prey equations to include disease dynamics, competition, and the Allee effect. The model describes the interactions between a healthy prey population susceptible to infection (S), an infected prey population (I), and a predator population (P). The changing densities of these populations over time are described by a set of coupled ordinary differential equations. For the simulation, we used Euler's method. This first-order approximation technique allows for observation of the temporal evolution of the three populations (S, I, and P) under varying conditions, revealing diverse dynamic behaviors. The results indicate that variations in the infection rate can lead to transitions between stable states, periodic oscillations, and chaotic behavior. The Bifurcation analysis maps out these transitions, providing insight into the model's stability and the potential for complex patterns.

3:45 pm: Matthew Stempel

Modeling Earth-Mars Transfers Using the Euler Method with a Dynamic Step

Since the beginning of space exploration, accurate trajectory prediction has been necessary for mission planning to ensure that the spacecraft will arrive at its desired destination. In this project we simulate Earth-Mars spacecraft trajectories with the goal of optimizing launch conditions. We implement the Euler method with a dynamic step size and vary initial conditions such as velocity and launch date to minimize time of flight and distance from Mars upon arrival. Finally, launch dates and trajectories were compared with historical Mars missions to evaluate accuracy of the model.

4:00 pm: Noah Kerzner

Simulating Self-arranging Myxococcus Xanthus Bacteria

The soil bacteria Myxococcus Xanthus bacteria is famous for its collective organization, intercell communication, and collective decision making. An agent based model based on the M. Xanthus model by Zhang et al was used to simulate M. Xanthus group dynamics. In this two-dimensional model, each bacteria is an agent characterized by position and moving direction, and is capable of self propulsion. Each agent deposits slime and chemical signal to a trail field and chemotaxi respectively. Bacteria align with their neighbors and the trail field and periodically reverse as a function of chemotaxi density. We find aggregation dynamics of M. Xanthus that do not agree with experimental results but instead feature a set of unique characteristics. Improved aggregation is observed when including a chemotaxi.

May 5 (ACWS 204)

3:00 pm: Zhixing Pan

Computer Simulation of the 3D-Ising Model

The Ising Model is a model which is used to study the phase transition of a ferromagnetism system. On a lattice each site i has a spin up, $S_i = 1$, or a spin down, $S_i = -1$. The energy of the system is $E = \sum_i^N \sum_{j>i} J S_i S_j$. The magnetization of the system is $m = \frac{1}{N} \sum_i S_i$. At high temperature $m = 0$, when spins are randomly spin up and down. At very low temperature, the system is in the ordered state, meaning all spins are up or all spins are down. This phase transition from ordered to disordered state occurs at the critical temperature T_c. We used the Monte Carlo Stimulation, specifically the Metropolis Algorithm to simulate the 3D Ising model. We find that for the 3D Ising Ferromagnet $T_c = 4.5$ which is larger than $T_c = 2.27$ of the 2D Ising Ferromagnet, and which is consistent with previous results of the 3D Ising Ferromagnet.

.