CENTER FOR
POWER OPTIMIZATION OF
ELECTRO-THERMAL SYSTEMS

Howard University | Stanford University |
University of Arkansas | University of Illinois at Urbana-Champaign

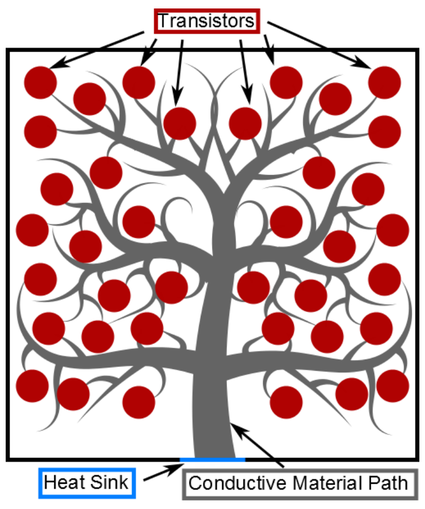
AN NSF SPONSORED CENTER

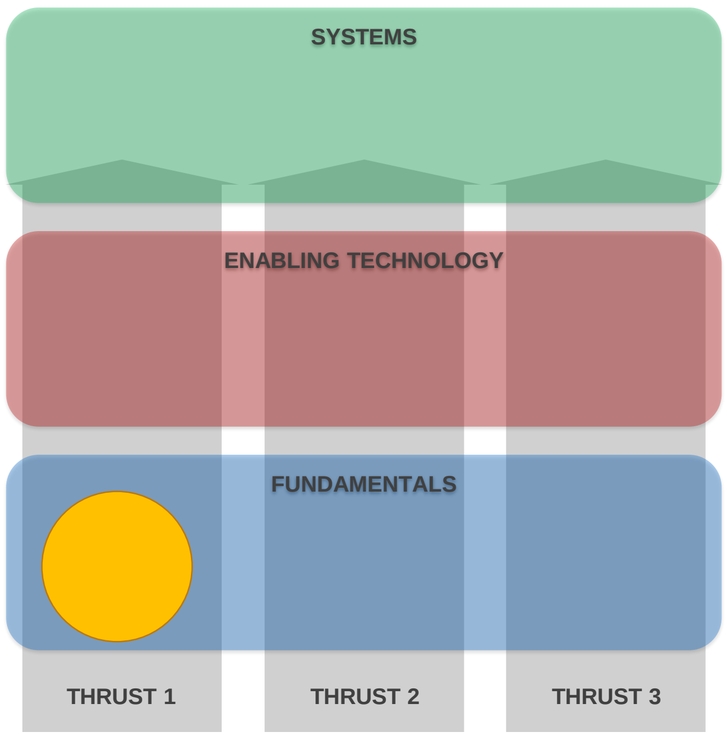
Generative Design of Optimal Thermal Management Systems

Investigators: Danny J. Lohan (UIUC), James T. Allison (UIUC), Ercan M. Dede (Toyota)

How can generative algorithms be used to design integrated thermal management systems?

- Thermal management systems are vital in preserving the performance of power systems.
- The concurrent design of power source placement and cooling channel topology allow for a more complete exploration of design space when optimizing to increase power output.





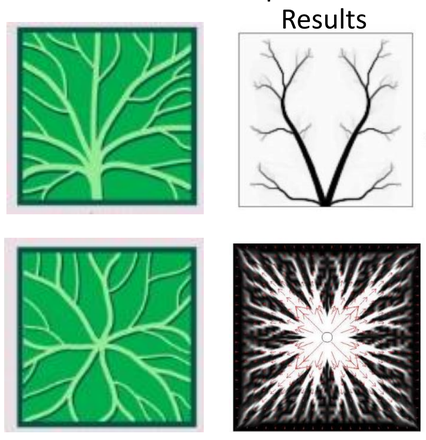
Vision: Using generative design procedures to design both floor plans and path plans would increase power density

Methodology

Motivation

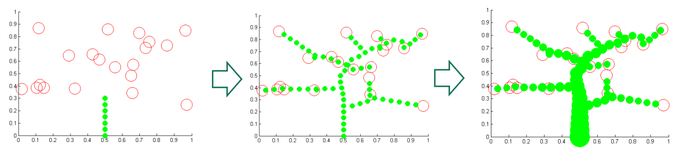
Topology optimization results from literature resemble venation patterns

Venation Patterns | Topology Optimization Results



Generative Algorithm of Interest

Space Colonization Algorithm (Adam Runions)



Place Auxins | Vein nodes grow towards auxins | Thickness is distributed

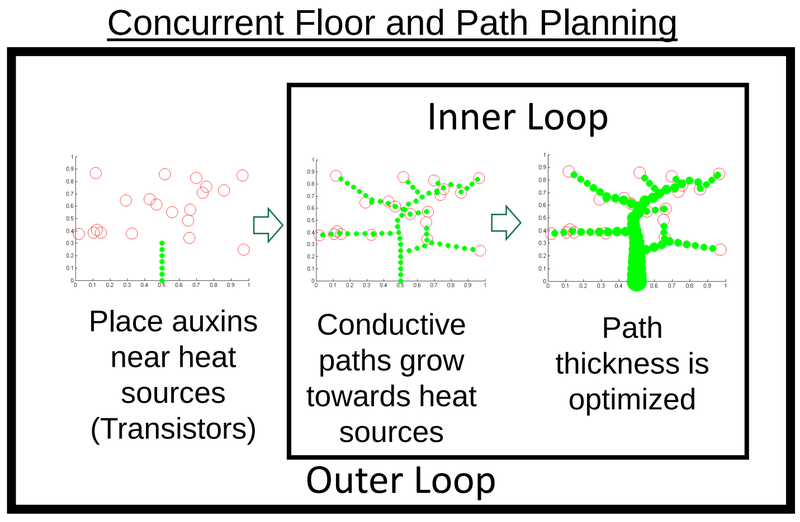
Key Features of Space Colonization Algorithm

- Fast acting algorithm
- Relatively low design variable count
- Single variable guides material distribution
- Veins do not intersect
- Intuitive translation to thermal management system design

Optimization Procedure

Objective: Maximize power output maintaining heat threshold
Outer Loop: Genetic Algorithm to determine heat source placement
Inner Loop: Gradient based method to solve for thickness of paths given limited material

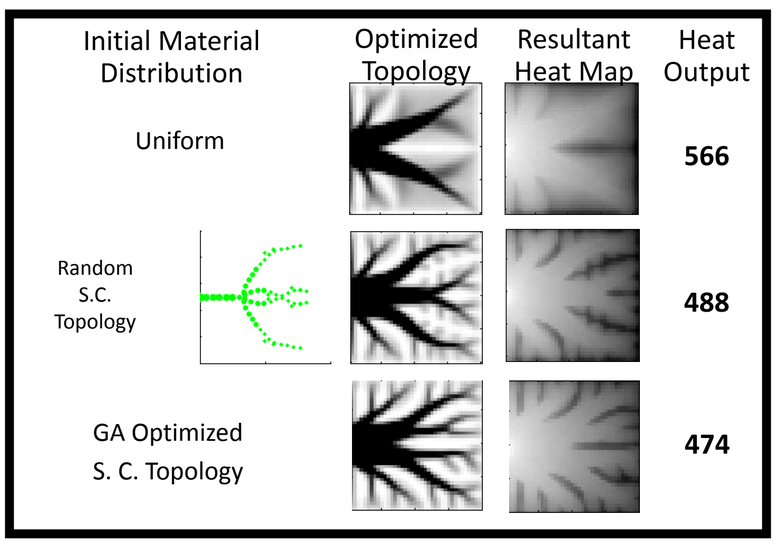
Concurrent Floor and Path Planning



Initial Results

Assessing Generative Algorithm Effectiveness

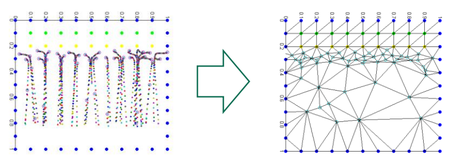
- Space colonization output was mapped as an initial material distribution on a discretized domain, then standard SIMP procedure was implemented to optimize topology.
- System heat reduction of **16%** was observed



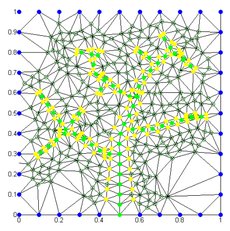
Granted generative algorithms showed promise when coupled with standard optimizing method, a stand alone solver is being developed.

Force Direct Particle Generator for Meshing

- Developed to address the issue of non-conformal meshing



- Particles are shot out from a generator.
- They are latched onto the nearest fixed node
- Charges repel particles from each other
- System is allowed to reach equilibrium
- Delaunay triangulation to mesh



Future Developments

- Optimization of mesh generator to form well shaped elements.
- Integration of a simplex finite element solver
- Embedding heat transfer physics into the space colonization algorithm
- Combining algorithms to solve for power density

P / O / E / T / S