A MYSTERY OF TIME

byTessa Shockey

Dr. Ian Gravagne,

BAYLOR ECS ASSISTANT PROFESSOR OF ELECTRICAL AND COMPUTER ENGINEERING,

is involved in researching a mathematical and engineering mystery indicative of mysteries found in science fiction novels.

Along with Baylor Distinguished Professor of Electrical and Computer Engineering Robert Marks and Associate Professor of Mathematics John Davis, Gravagne studies the applications of mathematical theory in calculus to find practical uses in the field of engineering, specifically as it applies to self-generating domain.

"We make use of two principle bodies of mathematical theory, discrete and continuous time mathematics, to analyze and understand and design engineering technology," he said. "Engineers are taught about the things that apply to discrete time math with the understanding that the gap between times is constant and fixed."

The theory of calculus is established on continuous math functions. "That's just fancy words for mathematical objects whose inputs span a continuous range of numbers," Gravagne said. These two paradigms, discrete and continuous, do not normally intersect; engineers historically have used one or the other. Recently, a new realm of mathematics has emerged where an intersection of the two can be studied.

"When that body of mathematics began to emerge, while interesting, it was essentially a mathematical curiosity," he noted.

Gravagne uses biological systems as an example of time scale mathematics. In growing season, plant populations grow continuously throughout the growing season.

"When that first frost hits and leaves behind a discrete number of seeds, then there is a gap in time between that and when anything happens again," he said. Scientists don't know how to reconcile such gaps with the population dynamics in play during the growing season. "That's a mystery of discrete and continuous mathematics."

It is this mystery that Gravagne seeks to flesh out. "Our research here focuses on whether there is utility for that type of mathematics in the engineering realm and, if so, what utility." A tremendous amount of mathematical machinery is needed to research this utility in engineering.

He looks for cases where problems do not easily fit into either the continuous or discrete time paradigms, particularly cases involving vehicles, airplanes and complex manufacturing systems.

For example, computers act on commands from humans, but computers also act and influence the actuators that cause change in the environment. All communication with actuators and sensors travels along the same pathway, and sometimes communication gets messy when there are multiple channels and commands to which the computer must respond. This may cause timing to get out of sync.

"Now we're talking about a time scale, or time domain, that doesn't fit within the normal paradigms," he said. This aberration from the normal forms a focus for his research.

"This is fundamental, basic research. It's the type of stuff that has to happen at universities because it really can't happen anywhere else without a commercial motivation behind it," Gravagne pointed out.

This research is still in its infancy, but he is thankful for the opportunity to be involved and for Baylor's support.

And Baylor is pleased to have Gravagne on faculty as his research, scholarship and teaching garner attention from beyond campus. His time scales research has been supported by more than $450,000 in grants from the National Science Foundation (NSF).

Gravagne was honored with the 2008 Achievement Award for New Scholars in Mathematics, Physical Sciences and Engineering from the Conference of Southern Graduate Schools.

And, he was awarded a $145,000 grant from the NSF to be used in Baylor's Engaged Learning Groups (ELG). Gravagne teaches a class on energy in the ELG (*see pages 12-13*) in addition to his undergraduate and graduate courses. He also has a patent pending for his redesign work of Curves® workout machines.