Mid-Semester Report

My name is Travis Hite, and I am a student working with the Research Experience for Undergraduates program funded by the National Science Foundation. My home college in Kennesaw State University, however I plan on transferring to UGA sometime in the next year. The specific REU I am attending is being held at the Auburn campus, and is in the general field of computer science and engineering.

My experience here began with a series of presentations presented by Dr. Biaz as an introduction to our experience here at Auburn. It was a good transition into the work I would be doing since it was more like I was accustomed to. In general, education for me since I have started has been a teacher presents a topic and explains his knowledge to me, imparting his wisdom to me in the process, and I prove to him that I remember everything important about what he told me. Getting past the standard concept of the educational experience would be one of the most important distinctions about graduate studies that I would learn.

The presentations were mostly over networking concepts, of which I was rather familiar at the time. However, Biaz produced a far more in-depth analysis of various network strategies than I had been presented in my classes. He also taught us various research strategies and told us some very important things to understand about the graduate experience. I found the information on various forms of funding the most interesting, as I had not heard of these before. I also found his information on publication to be enlightening.

The next week we were to choose a mentor to work with for the rest of the experience. While some of the presentations contained ideas that were indeed revolutionary, I did not find many of them to be extremely interesting to me. After a few professors presented their various projects, we were free to walk around and ask questions on our own time. With a little research I was able to find out about Dr. Dozier, who interested me because he listed artificial intelligence and genetics as his areas of interest.

I met with Dr. Dozier for roughly an hour, and he showed me a robot that he was working on that he could use another researcher to help his team with. The robot is a Khepera robot that is roughly 55 millimeters in size. It has two wheels, one on either side, and some smooth parts on the front and back to keep it from toppling one way or

another. It has 6 infra-red senors on the front and 2 sensors on the back. The front sensors had been set to a mode that can detect distance from an object, and the back sensors had been set to receive light sources, though for our particular experiment it has not been used.

The concept of the robot is to use interactive genetic algorithms to design a robot that would avoid walls with no programming bias and with as little user fatigue as possible. Through a method designed by a team under Dr. Dozier, the robot is capable of producing results in a matter of minutes whereas most interactive evolutionary robots take several days to produce results. The reason it is able to do this is because for a defined number of iterations the robot takes two individuals from a randomly generated population and has them participate in a tournament scenario. I will discuss later the finer details of this scenario, however the user preference is remembered for every scenario and stored for later use. After so many iterations, the robot will shut down and "meditates" on previous entries. It continues to take two individuals and place them in tournaments, however it uses previously stated user preferences instead of current user preferences to conclude who is the winner of the tournament. This is also continued for a user defined number of cycles. At the end a winning weight is chosen based upon past experience.

The concept intrigued me mostly because there was so much one could do with it. One scenario I was presented with was a quadriplegic man who could not move to perform tasks on his own. However, if he could somehow instruct the robot to perform the task, and to teach it how to do its task better, he could continue to be a productive member of society and maybe even maintain a useful and profitable job.

I was very pleased the next day to find out that Dr. Biaz had accepted me to work under the wings of Dr. Dozier. However I found out the next day that Dozier was going to be out of town for the rest of the week, leaving me on my own with no real project to work on. Instead I spent the week reading over various programming books and other resources I could find parallel to the field so I would have a little more working knowledge coming in to it.

The first thing Dozier had me work on was making a better interface for the robot. He did not want me to get into deeper workings of the robot at this point because there was a lot of information he needed me to understand

first before I could actually do anything with the robot. The current interface was a button presented on a webpage that you would click whenever the robot was doing something you did not want it to do. This would adjust the fitness of the robot, and be used in the evaluations at each tournament level. What Dozier wanted was some form of live streaming webcam to be placed over the robot. This way, we could leave the robot running at all times and could observe and interact with the robot remotely.

I performed a little research on this area. Apparently java has a media package that is handled to handle just this. However, java handles this by buffering the information first to a file, and then streaming this file continuously to someone else. This buffer causes delays, and the best research paper I could find on this claimed to only have this delay down to eight seconds, which was not acceptable as two different individuals would have already been ran during this time and we would be on an entirely new individual. Dozier decided at this time it was best to skip the webcam interface, as it would take far too much time to actually use.

The next thing he wanted me to do was study the ins and outs of genetics. He presented me with several papers to read, a book to read, and finally a paper on the robot that he himself had published.

The book, “Evolutionary Robotics” by Stelfano Nolfi and Dario Floreano presents detailed information on various design methods used in creating evolution concepts, and different ways to go about it. I later presented my findings to the research group.

Dozier's paper was also fascinating. In it he went over details of past evolutionary robots. While many robots will use as many as 48 different weights for preformance, Dozier's robot has simplified this to just 4 weights to be used in a polar fashion. The fourth weight, the sigma value, is the overall speed of the robot. This speed ranges from one to 512. The higher the sigma value, the slower the robot will go. For our experiment purposes, we want the robot to go as slowly as possible in order to keep the robot from performing destructive behaviors.

The other three values speed down the wheel on the opposite side of the sensors based on the readings of the sesnors. Once they have passed a threshold of 1023 on either the front, mid-front, or mid-back sensors, a number between negative 30 and 30 is used, and depending on the

value either speed up or slow down the wheel. An optimal response here is -30, which would slow down the wheel enough to get the robot to turn away from the wall.

The basic programming of the robot as referenced here can be considered the genotype of the robot. However, "hits" made by the human interaction are based on the phenotype of the robot, or rather the characteristics of its movements. Hits are applied to the robot any time it comes dangerously close to the wall, moves erratically, or moves far too fast. For the purposes of our experiment, a hit is also applied any time the machine turns, since this would result in more hits for algorithms holding a faster sigma value.

If an individual produces a result the program considers to be dangerous to the robot (very fast, hits walls very often), the individual is then aborted to keep damage from occuring to the robot.

The way the tournament works is that two individuals are chosen from an initial population and allowed to interact with the robot for 4 seconds. The computer then compares the number of hits, and whoever has the least hits is considered the winner. If the second individual is infeasible, uniform crossover is used. In uniform crossover, a new individual is created using the weights from the parent. For instance, {-19,21,-5,412} and {-2,-28,4,58} may result in {-19,-28,-5,412}. This is used to effectively search the gene space and find the most appropriate individuals. This crossover overwrites the losing individual, and the winner is placed back in the population. A new individual is now set into tournament against the losing individual.

Uniform-bounded mutation is applied when both parents are feasible (that is, has at least two recorded wins and has not been aborted). In this case, the losing parent is overwritten with a mutation of the parent. Mutation in this context would be to add or subtract an amount from each weight to create a new individual. For instance, we could use {-12,12} to modify the first three weights, and {-50,50} to modify the second weight. Say we have an individual {-24,-18,-4,486}. A potential mutation could be {-15,-26,-10,510}. Anything out of bounds of the mutation (say trying to turn the first weight into a -32) is properly bounded to keep results inside our control.

Finally, if both candidates are aborted, then a random candidate from the population is mutated twice and replaces

both parents. This is used to keep us from trying to use any potentially dangerous individuals again that might danger the robot. From there the process is continued as stated above.

In the meantime while I was reading the papers I also attended a class presented by Dr. Dozier three times a week over evolutionary design. This class greatly aided in reinforcing my understanding of the concepts presented and gave me a great launching ground for the research I was to perform.

With this knowledge in hand Dozier presented me with various scenarios and a problem. The problem was that generally good weights are determined by the algorithm as stated above. However, the sigma value it produced would often be rather dangerous. The idea was given to me to try and produce new operators that would better get us to our goal. It was found that the largest part of the problem was difficult with the human factor in trying to assign negative fitness to fast speeds. Since the difference between 256 and 512 is so hard to tell by just watching the robot, often these things are overlooked.

I presented several ideas to Dozier, including using an Elo system to assign a number to them to qualify how good the individual is. However, we have come across another route to be considered. We are currently trying to build in a naive bayesian modifier into our system. The way this modifier works without going into the details of it too much is to find the probability of a hypothesis using several events as qualifiers. Using these probabilities the best alternative can be found to a situation. We are going to try applying this to our mutation rates. Hopefully, this will steer our results towards a specific direction with better frequency and with more speed.

As of the writing of this midterm report, I am currently using this system to go over the results of previous runs and try to figure out where the results end up going in the wrong direction on failed experiments. With this information we may be able to strengthen the procedure in new ways.

This experience has opened my eyes to a new experience I had previously hardly known the existence of. The most important thing I have learned from this experience is how to research an area of interest and how best to go about learning. Beforehand when I would read a paper I would merely go over it and put it down, more than likely never

reading it again. Now I am sure to read a paper multiple times before I consider it properly digested. I am noticing on the re-reads that I am picking up on things that I did not notice before and information that was confusing on first read is becoming far clearer.

I have also gained valuable experience in working together with a team in order to produce quality results. Throughout this experience I have never felt alone in my studies. Conversing with the other people in my research group about the problems that I am experiencing has taught me almost as much as the research itself has taught me.

I would also like to mention how much I have enjoyed this experience. Thanks to the REU program I have met a wonderful group of people that without which I would have never met before. Without the REU I would more than likely have been working away my summer doing something I did not enjoy just for the ability to be able to afford another year of college. I am extremely grateful for the opportunity that has been extended to me.

I feel when I return back to normal college in the fall I will be far more prepared for the learning process, and will be able to tackle it in ways I was not previously capable of. At times during this project I have felt like I have been dragged about from one place to another in order to produce results. However, as the project goes on this feels less and less like the situation, and I am slowly evolving into someone who is capable of performing research without having to be dragged around and prodded.

I still feel as if I have a lot to learn, and the mere months this experience has given me will not be enough truly become used to it. I am also not sure if this point if I do wish to continue into the graduate level of studies. Several positive as well as negative aspects have been presented to me that I had not seen before. Time will only tell.