**A Fuzzy Flute**

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CSc-180

Sprint 2017

Project 1 - EXPERT SYSTEMS / FUZZY LOGIC

**Introduction and Background**

Native American flutes are a deep and challenging topic in that the flutes carry a huge cultural history. The Native American flute is rooted in the traditions of the Western world and a select few have carried on the tradition of creating and sharing the intricate woodworking methodologies. Most flutes are handmade and have 5-6 holes, and sometimes 8. Their unique sound can be affected and altered by a variety of internal and external influences including the type of wood, the chamber size, mouthpiece size, and even the size and spacing of the finger holes.

Our expert system’s goal is to aide a new flute woodmaker in designing and creating their unique flute, as well as present some help with the issues they may face.

**Knowledge Engineering**

Mr. Robert Castlebary was chosen as our expert for his detailed knowledge in the history and making of traditional Native American flutes. For more than a decade he has designed and built custom Native American Flutes as both a hobby and side business.

Our team met with expert for a few hours and asked him various questions about his experiences. He showed us many examples of both incomplete and complete flutes and he walked us through his process of building a flute. After spending this time we were able to then refer back to him and ask for clarification on things when they didn’t make sense.

As far as making simplifications go; it is clear that constructing flutes of these types is very difficult to model accurately due to the nature of woodworking and the many number of variables. We simplified our program to focus on the more general ideas that can be found in the construction of Native American flute construction.

**Expert System Design**

There were two instances we thought we could implemented fuzzy logic in. The first being the intricate placement of the holes, the second being the effects that temperature had on the tuning of the instrument. Our expert had a desktop program he used to calculate the placement of the holes. After investigating the desktop program, we decided there were too many measurements and factors that we would have had to take into consideration. We decided to go with the second option of determining the size of a specific finger hole based on the temperature of instrument and the frequency of the instrument.

During the tuning of the instrument, in order to tune a finger hole to the optimal frequency, the instrument’s temperature must be taken into account. It is estimated that the instrument’s pitch changes by 3/100’s of a semitone of 3 “cents’ per degree Celsius (Sengpiel). The optimal tuning temperature was found to be 22 degrees celsius (Gale).

First the program asks the user a series of questions after which it performs analysis using the knowledge that we obtained from our expert. These are more general questions and don’t deal with exact numbers. If the flute can be built, then the user is asked about tuning. This is a difficult process and can take hours of measurement and temperature is taken into consideration when a flute is constructed. The program then provides outputs for how to adjust the tuning of one hole on the flute. Keep in mind that this expert system could be expanded to provide much more detailed analysis on all of the different holes present on a typical Native American Flute.

**Conclusion**

We were both excited at how well the program seems to work. Because we chose to simplify some of the concepts in order to give a better overview of the whole construction process this still allowed us to implement the concepts in the class (creating an expert system along with fuzzy logic) while still being able to have a complete and relatively bug free program at the end. We did have trouble getting the fuzzy controller for tuning to work however, it seems to be working much better with further tweaking and testing. Gabe seemed to notice some situations where FuzzyClips was not cooperating with file system updates which took some time to understand what was going on.

**APPENDIX A (installation guide)**

Once Clips is installed and working on your computer, you will need to open the file. Navigate to the NativeAmericanFluteExpert.clp file using the Load Constructs option in the menu. After the file is loaded, you should see a series of lines of text on the screen. This is the program building. In order to make sure that the program is ready to run, type the following commands followed by enter. Please note that the double quotes should be omitted when you type but the parenthesis are important.

“(reset)”

“(run)”

This set of commands will launch the program and you will be required to type in your responses. If you make a mistake, simply continue to type until the program ends and then repeat the following commands that you see above.

**APPENDIX B (user's guide)**

For the most part, the program will guide you through the process. Simply type in responses when you are prompted and the output should appear on the screen. If you make a mistake, see the end of APPENDIX A for instructions on how to clear it. There is only 1 situation where you will not be presented with the tuning guide and that is when you have an oak flute blank that is not properly finished. Other types of wood can have imperfections inside the flute blank and function fine. However, oak has a tendency to leak air if not completely and properly sealed. This is why the program will tell you that you have a “bad blank” and to start over. This isn’t a problem with the input but a warning to the user that the flute that they are constructing is not worth finishing because, in all likelihood it will not be playable at the end.

**References**

**Robert Castlebary (expert)**

**Gale, Bruce. "Pitch and Temperature." The Concert Band, n.d. Web. 03 Mar. 2017.**

**Sengpiel, Eberhard. "Change of Pitch with Change of Temperature." Sengpielaudio.com, n.d. Web. 03 Mar. 2017.**