

What is the Project title?***Neural Step-work***

(aka Ranch Ranch Ultimate Chinchilla aka Dance Dance Autocorrelation)

Who is in the group?

Kylie Chesner, Lukas Gross, Ryan Swei

Give a high-level description of what you want to do.

We will create a program that generates a step chart for a given audio track for the popular rhythm game Dance Dance Revolution (DDR)/StepMania.

Explain why this is this an interesting/useful/cool thing to do.

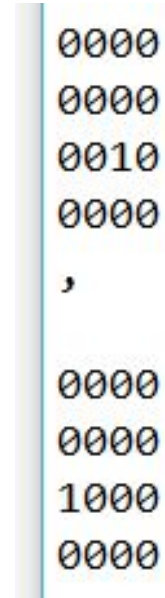
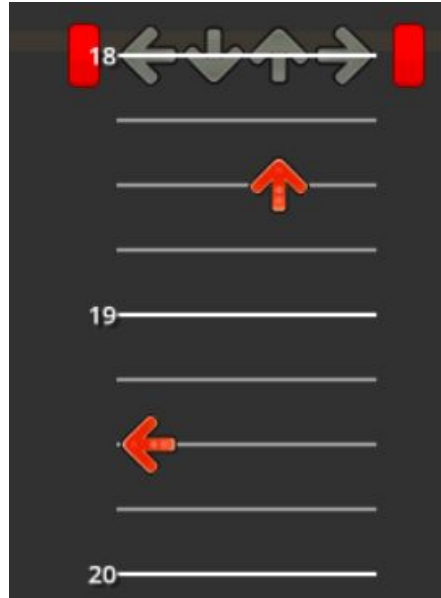
Building a new step chart in StepMania manually is extremely time-consuming and meticulous. The player must manually determine song metadata like the bpm, which is subject to human error. It also is difficult to manually create “fun” step charts, because randomly placed arrows that are on beat don’t make a step chart fun to play.

What prior art is there? Give citations. Is there a commercial product that does something like this?

There is existing software¹ from the University of California, San Diego that solves this task, as well as a patent² held by Samsung Electronics Co Ltd. The existing work, Dance Dance Convolution (DDC), is broken up into two parts: step placement (timing) and step selection (up, down, left, right). DDC uses a neural-network model that has no concept of tempo, instead assuming that each song has measures with a precision of 192nd notes at 125 BPM. This leads to charts that are confusing to play because steps do not appear at normal notes divisions (quarter, eighth, etc). Another criticism of DDC is that it performs poorly for easier difficulties, which was the premise of a later paper³ on a system that learned the fine gradation of difficulties for step-chart generation. There is a great deal of prior art for beat tracking, for example a paper⁴ published in 2003 which describes an efficient algorithm for estimating time-varying tempo.

What is the exact task that your system will do?

Our system will take in a .wav audio file as input. Users will also have the option to enter song metadata such as title and artist. The system will write a simfile (.sm) placing a series of arrows on identified stressed beats to create the step chart; we will only place 4th, 8th, 12th, and 16th notes. Specifically, each measure in a step chart is represented by a matrix; a zero means no arrow is at that time, and a nonzero value means there is an arrow (see figures below of a step chart loaded in StepMania and the simfile representation of a step chart). Once the arrows are placed, the system will output a zip folder containing the files needed to play the new step chart in StepMania; these files include the original .wav file as well as the simfile containing the step chart information and song metadata.



What measure will you will use to evaluate performance of what you build?

We plan to evaluate the accuracy of our bpm detection by comparing bpm's identified by our system to the corresponding official bpm's of a set of DDR tracks. We plan to implement a recurrent neural network to determine what arrow type is placed at a given beat. As done in the DDC paper, we will use perplexity to evaluate the performance of the RNN.

Is there a data set that your system can be tried on? If so, what is it (give links). If not, explain why not. Where will you get it? Do you have to label it yourself or is it already labeled? How big is it? How many examples? How is it encoded?

Our system can be tried on a set of official step charts from released Dance Dance Revolution games. The following link (https://zenius-i-vanisher.com/v5.2/simfiles.php?category=top_official) provides hundreds of official step charts that can be used for training/testing models which are already encoded as simfiles, including 50 of the most-downloaded step charts. This link (<http://stepmaniaonline.net/>) provides download access to hundreds of thousands of community-made step charts we can also use to train an RNN model.

What is the baseline approach you will compare your system to? Random performance? An existing system? Human performance? Be specific.

There is a lot of subjectivity in what makes a step map "good." Therefore, we will compare our system's output to official simfiles and DDC simfiles with blind user testing. We will have each participant score the played tracks on a scale of 1-5 on several aspects of the track's quality, such as funness, footwork difficulty, and chart prettiness.

Describe any existing software packages you will use. Where will you get them? Give links. Have you already tried them out? If not, why not? If so, how did that go?

- LibROSA

- Package for music and audio analysis.
- We have used this before for homeworks; it generally works well and has good documentation.
- <https://librosa.github.io/librosa/>
- **Essentia**
 - Library for audio and music analysis
 - We have not used this yet (we are starting with LibROSA), but it was used in the “Dance Dance Convolution” paper.
 - <https://github.com/MTG/essentia>
- **TensorFlow**
 - Neural network software
 - Our group has used it before with success.
 - <https://www.tensorflow.org/>

Describe any software will you need to write. Are you plugging two existing projects together? Does that mean writing a wrapper?

We will write software to determine at what beats to place steps on. For now, we may first determine the tempo of the song and train a decision tree to do step placement or use some other method. We then will use an RNN for determining which arrow type(s) should be placed at each beat based on the RNN used in DDC. The RNN will take as input a list of matrices representing the measures in the song (see the rightmost figure above under the “exact task” question), and this list is contained in the simfile for a step chart. The thousands of training examples needed for a high-performing RNN will come from the two sources previously linked. Finally, we will write software to create simfiles that can be imported by players into StepMania.

What are potential obstacles to success? Do you need to learn a new language? Is there some data you don’t know how to collect? Something else

Currently, the most ambiguous part of our plan is determining what is the best method for beat tracking and arrow placement. Once we solidify our method, we can integrate a modified version of DDC’s RNN into our project.

How will you QUICKLY determine if these obstacles will stop you? Describe a CONCRETE way of finding out if these obstacles will make it impossible to complete your plan in the next month. You want to know early, so you can change your plan.

To start, we will use existing libraries for beat tracking (e.g. LibROSA). To determine proper beat-to-arrow placement, we plan on reading several academic papers on beat tracking and similar subjects to guide us. To ensure that we can overcome these obstacles we have included them early on in our milestone timeline so that we can fail quickly.

What other tasks (besides coding) will you need to do? Data collection? User survey? What do you have to learn/know/get before you can start these tasks?

We have access to the full datasets used in both prior papers, as well as many more tracks available online (link given above). This should be a sufficient dataset for our purposes. We will

need to perform user testing in order to determine the effectiveness of our approach, so we will need to learn how to properly conduct a study and find participants.

Milestones What will you complete by the date of the first meeting with a TA/Professor report?

We will look into basic beat tracking with LibROSA and figure out how simfiles work by creating and loading one manually. We will have all the data we want to use to train our RNN collected as well.

What will you complete by the date of the second meeting with a TA/Professor report?

We will have identification of stressed beats in place. We will be able run an audio file to a simfile end to end no matter how bad the generated step chart is. Since the RNN likely won't be done by this point, we will use a random number generator to randomly choose what arrow type should be used at an identified stressed beat.

What will you complete by the final presentation?

We will have implemented the RNN responsible for assigning stepped-beats a particular arrow type. We will also have our poster and website text.

Who is responsible for each milestone?

We plan on having everyone contribute to each milestone, but the following is a map from each group member to their primary responsibility.

Ryan Swei: Finding BPM, implementing website

Kylie Chesner: Determining stressed beats

Lukas Gross: RNN training and writing a simfile manually

Works Cited

[1] Donahue, Chris, Zachary C. Lipton, and Julian McAuley. "Dance dance convolution." Proceedings of the 34th International Conference on Machine Learning-Volume 70. JMLR. org, 2017. <https://arxiv.org/abs/1703.06891v3>

[2] Park, Young-Sik, and Jeon-Man Park. *Method for Automatically Creating Dance Patterns Using Audio Signals*. <https://patents.google.com/patent/US6433267B2/en>

[3] Tsujino Y., Yamanishi R. (2018) Dance Dance Gradation: A Generation of Fine-Tuned Dance Charts. In: Clua E., Roque L., Lugmayr A., Tuomi P. (eds) Entertainment Computing – ICEC 2018. ICEC 2018. Lecture Notes in Computer Science, vol 11112. Springer, Cham https://link.springer.com/chapter/10.1007/978-3-319-99426-0_15

[4] Laroche, Jean. "Efficient tempo and beat tracking in audio recordings." Journal of the Audio

Engineering Society 51.4 (2003): 226-233.

<http://www.ee.columbia.edu/~dpwe/papers/Laro03-beattrack.pdf>