A Stage Performance that Combines Live Coding for Stage Lights and DAW-based Music Performance

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***Abstract*—We are exploring unique stage performances based on live coding. In this study, we have realized a live coding performance of stage lights and music by combining live coding to control stage lights with music performance using a DAW (Digital Audio Workstation). More than just a performance that combines stage lights and music. This study is significant in that it has enabled a performance that complements the two by seamlessly connecting the dynamic control of stage lights through live coding with the static music performance using a DAW. In this study, we have implemented a program based on the live coding system "Sonic Pi" to control 10 stage lights, as well as a program using the Processing language that links Sonic Pi with the DAW "Domino" and controls the stage lighting in response to the music based on real-time analysis of music playback using Domino. This study makes it possible to realize unique performances that use live coding of stage lights to create a stage performance based on music genres such as classical and pop.**

***Keywords*— Live Coding, DAW, Performance, Stage Lights.**

I. Introduction

Live coding means writing and executing a program on the spot, and is a common practice in programming workshops and the like. However, if we consider the improvisational act of coding as a means of expression, live coding can also be seen as a form of performance art [1]. In fact, live coding as performance art has been attracting attention in recent years, and the live coding in this study is intended to be that way.

We are exploring live coding as performance art. We have demonstrated a unique live coding system that controls stage lighting simultaneously with musical performance [2]. We are also developing an extended live coding system for VR and AR. Through this research, we have gained a variety of insights into live coding.

The mainstream live coding is music live coding, which is highly compatible with songs with mechanical, rhythmic, and repetitive minimal beats. Conversely, it is difficult to handle songs from genres such as classical and pop music using current music live coding. Live coding is programming after all, and is not a method specialized for music. But, we aimed to make it possible to handle classical and pop music using live coding.

In this study, we have achieved a live coding performance of stage lights and music by combining live coding to control the stage lights with music performance using a DAW (Digital Audio Workstation). More than just a performance that combines stage lights and music. This study is significant in that it has enabled a performance that complements the two by seamlessly connecting the dynamic control of stage lights through live coding with the static music performance using a DAW. In this study, we have implemented a program to control 10 stage lights based on the live coding system Sonic Pi[3], and a program using the Processing language that links Sonic Pi with the DAW Domino[4] and controls the stage lighting in response to the music based on real-time analysis of music playback by Domino. This study will enable the realization of unique performances that use live coding of stage lights to create a stage performance based on music genres such as classical and pop.

This paper is structured as follows. Section 2 describes the background of this research, namely, live coding as performance art and DAW as music production software. Based on this, Section 3 describes the basic goals, policy, and approach of this research. Section 4 then provides an overview and implementation of the prototype system, and Section 5 describes a stage performance using this system. Furthermore, Section 6 describes related research, and Section 7 concludes this paper.

II. Research Background

A. Live Coding

Live coding as performance art has been taking place around the world since 2000. Centered around TOPLAP, a live coding community founded by pioneering live coders such as Alex Mclean, live coding events such as Algorave have been held in various locations, and academic conferences such as ICLC[5] have been held annually since 2015. Live coding as performance art is dominated by coding performances that improvise the generation of music and video. Music live coding, in particular, is a popular performance style with a long history, as it is easily accepted as it feels similar to a live musical performance.

Many tools for live coding as performance art have been developed to date. Specific examples include music-based live coding tools such as Chunk, OverTune, TidalCycles[6], and Sonic Pi, as well as video-based live coding tools such as Fluxus, LiveCodeLab[7], and Hydra. Given their improvisational (live) nature, these tools are necessarily interpretive systems. In other words, they allow dynamic

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program additions and changes to be made to a running program, and these changes must be immediately reflected in the program's execution.

B. DAW: Digital Audio Workstation

A DAW is a system that is configured to perform a series of tasks, such as digitally recording audio, editing, mixing, and arranging music, but in recent years, it has often been recognized as music production software for computers. Examples of such DAWs include Pro Tools HD, Cubase[8], Logic Pro, Studio One, and Cakewalk. In this study, DAWs are considered to be music production software.

Music production using a DAW is often done via an input interface called a piano roll. This is a GUI for inputting musical information, and is the interface used by many DAWs. Entering musical information into such a piano roll is called "Programming." Programming can be done using a mouse, but it can also be input via an audio interface that connects an electronic musical instrument to a computer. A typical example of this is inputting musical information via a MIDI keyboard connected to a computer.

C. Issue

We consider live coding and DAWs to be complementary tools, not competing methods. Table 1 summarizes the characteristics of live coding and DAWs.

TABLE I: Live Coding and DAW

Live Coding	DAW
Not specialized in music→Can also generate video and control devices	Specialized in music→Music creation tools
Improvisation is the key	The basis is music creation
Input method is programming only (CUI)	Input methods include mouse and keyboard (GUI), as well as electronic instruments
Dynamic content creation	Static content (music) creation

By using a DAW to create the music and then live coding the stage direction based on that music, it is possible to create a stage performance that takes advantage of the characteristics of both.

III. MATH

A. Basic Goal

In this study, we aim to realize a live coding performance combining stage lights and music by fusing live coding, which controls the stage lights, with musical performance using a DAW (Digital Audio Workstation). More than just a performance combining stage lighting and music. This study is significant in that it enables a performance that complements the two by seamlessly connecting the dynamic control of stage lights through live coding with the static musical performance using a DAW. The stage lights used in this study will be moving lights that can change their direction both horizontally and vertically.

A. Basic Policy & Approach

The basic principles of this study are as follows:

- Utilizing music information, triggered by music performance using a DAW
  - Control stage lights in sync with music performances
  - Control stage lights using music information (scale, tone, etc.)
- Controlling stage lights with live coding
  - Dynamically generate and execute stage lighting control programs based on music information from a DAW
  - Perform improvisational operations that match the overall atmosphere and melody of the song
- Linking with existing music live coding systems

The live coding in this study is mainly focused on controlling stage lights, and not on generating and performing music like music-related live coding. There are many previous examples and related systems for music live coding. This research does not aim to create a new music live coding system that competes with these related systems, but rather aims to link with them. We believe that this will be of great significance if it becomes possible to simultaneously control stage lights with many music-related live coding systems.

Based on the above basic policy, this study will adopt the following approach.

- Linking a DAW and Live Coding System via MIDI
  - DAW: MIDI Output
  - Live Coding System: MIDI Input
- Interpreting Sound and Pitch Information Based on Synesthesia and the Dome Model
  - Synesthesia: Colorization of Sound (Color of Lights)
  - Dome Model: Sound Location (Lighting Angle: Horizontal and Vertical)

First, MIDI communication is used to link the DAW and the live coding system. MIDI[9] is a protocol for connecting electronic musical instruments, and most DAWs support MIDI. The data exchanged via MIDI is like musical notation and contains sound information. This music data is output from the DAW and received by the live coding system, which then analyzes the information to control the movement of the stage lights.

Next, we use synesthesia and a dome model to interpret musical information. Synesthesia is the reaction of multiple sensory organs to a single stimulus. There are various types of synesthesia, but one that is particularly well-known is sound synesthesia. This is a sense in which sound is perceived visually, and sounds evoke colors. In fact, the existence of people with this type of synesthesia has been confirmed. Research on people with sound synesthesia has been conducted to date, and although there are individual differences, it has been found that there are some commonalities. In this study, we will refer to reference [10] and map sounds and colors as follows (Fig. 1). Note that these colors are the light colors built into stage lights

C	D	E	F	G	A	B
Red	Orange	Yellow	Green	Blue	Aqua	Pink

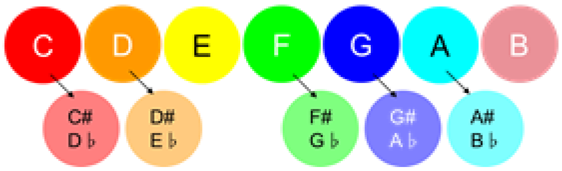

Fig. 1: Colorization of Sound based on Synesthesia

The dome model is a simple model that slices a hemisphere and associates the sound position with the light angle. This is almost the same model as the one we used in our previous research [2] (Fig. 2).

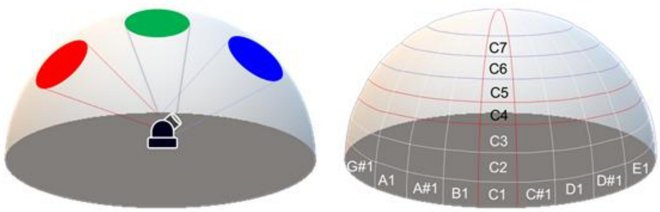

Fig. 2: Dome Model

The horizontal and vertical directions of the dome model correspond to the angle of light (horizontal and vertical directions) in lighting. Horizontally, the circle is divided into 12 equal parts to allocate notes, and vertically, 45 degrees is octave 4, with three octaves above and below it (Fig. 3). The brightness of the color also changes depending on the pitch of the note. High notes are set to a high brightness, and low notes are set to a low brightness. For example, the C in octave 4 is the same red as the C in octave 7, but octave 4 is a darker red than octave 7.

Fig. 3 Horizontal and Vertical Directions of the Dome model

IV. Units

In this study, we implemented a prototype of a live coding system that controls stage lights in conjunction with a DAW. The system configuration is as follows (Fig. 4).

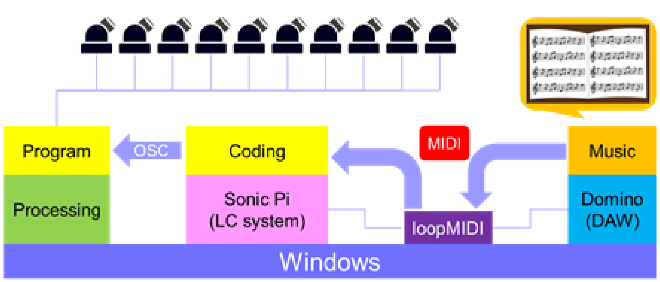

Fig. 4 System Configuration

The DAW used was Domino, a simple free DAW. Sonic Pi was used as the music live coding system. Communication between the two is via MIDI, and to achieve this smoothly, the free software loopMIDI, which creates a virtual MIDI port, is used. The basic operation is as follows: First, a MIDI file or input music information is played on Domino, and the MIDI data flows to Sonic Pi via loopMIDI. A program implemented in this research that analyzes MIDI data is started on Sonic Pi. The results of the MIDI data analysis are converted into control commands for the stage lights and passed to a stage light control program (implemented in Processing). Ultimately, 10 stage lights operate in sync with the music.

Since a program that controls stage lighting is generated and executed from MIDI information received from a DAW, it might seem that manual live coding is unnecessary. However, automating everything often results in a performance that lacks interest. This is because many classical and pop pieces, in particular, not only have many repetitive similar phrases, but also rarely have a pitch change of several octaves at once. This is why it is necessary to have the feel of a live coder, performing live coding that allows for a bird's-eye view of the song and dynamic stage lighting effects

V. Performance

The system implemented in this study was used to perform actual performances at art festivals and other events. For the performances, 10 stage lights (moving lights) and 10 sound equipment (speakers) were used, with lighting and music performances taking place throughout the entire hall (Fig. 5). All performances were based on classical music. The pieces used were Dvorak's "From the New World," Tchaikovsky's "The Nutcracker (Waltz of the Flowers)," and Pachelbel's "Canon." A questionnaire survey was also conducted among the audience, and the results were quite positive.

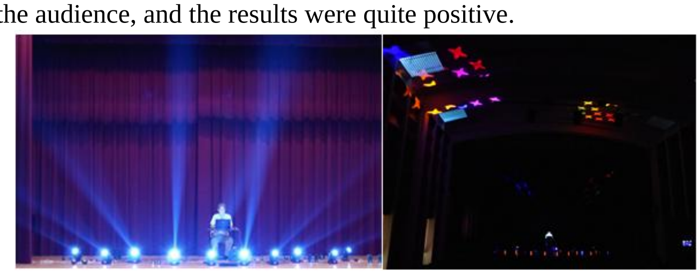

Fig. 5 Scenes from the Performance

VI. Related Work

The trends and currents in live coding as a performance art can be seen in the list of papers accepted for ICLC[5]. Looking at the papers to date, most of the topics are related to music and video, but on closer inspection, there is also research not just on the generation of music and video itself, but on the execution environments and interfaces for them. For example, there is research on live coding environments on web browsers. Recently, there has also been a lot of attention on the generation of music and video through live coding that incorporates machine learning and deep learning[11].

One example of research using live coding and DAWs is the work of C. Roberts et al.[12]. This research involved controlling a DAW called "Ableton Live" with live coding and has different goals and approaches from this study. Controlling a DAW with live coding can be seen as a collaboration between a DAW and live coding, but this is a different collaboration from the one aimed for in this study. They implemented a new live coding system, but conversely, it would be difficult to realize their research approach using an existing live coding system. In this study, Sonic Pi was used, but it would not be that difficult to use something like TidalCycles.

VII. Summary and Future Work

In this study, we implemented a prototype system that combines music performance using a DAW with live coding to control stage lights, achieving a stage light performance synchronized with music. This study is distinguished from related studies in the following ways:

- It allows you to create performances that take advantage of the benefits of static DAWs and dynamic live coding.
- It allows you to create music live coding that is highly compatible with classical and pop music.

The prototype system in this study is Sonic Pi, which is an easy-to-use system, but it is not very efficient in terms of execution, so we will consider integrating it with systems such as TidalCycles in the future.

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