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Rasmussen et al.

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(54) **SYSTEMS AND METHODS FOR A MUSIC FEATURE FILE AND COORDINATED LIGHT SHOW**

(58) **Field of Classification Search**

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This patent is subject to a terminal disclaimer.

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H05B 47/12 (2020.01)

G06F 3/16 (2006.01)

(Continued)

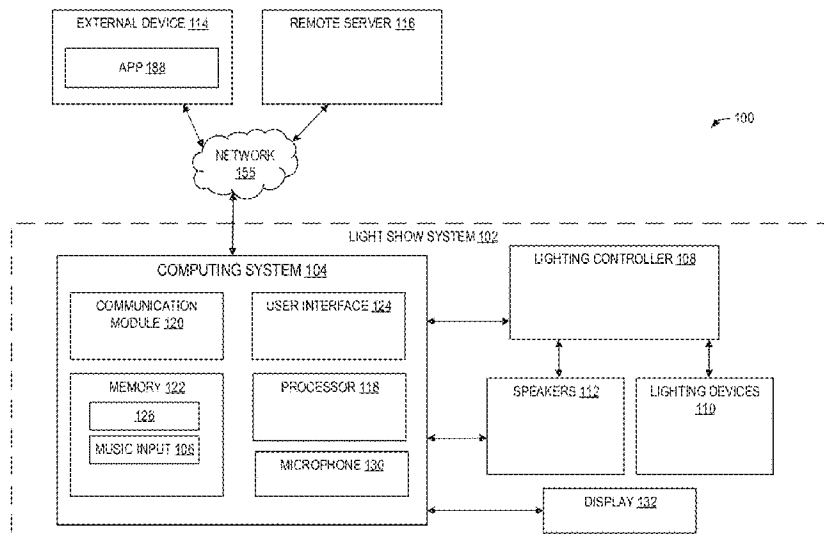
(52) **U.S. Cl.**

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(57) **ABSTRACT**

Examples are disclosed for systems and methods for providing an automated light show synchronized to one or more music files. In one embodiment, a method comprises generating a music feature file based on selected audio, the music feature file comprising metadata for the selected audio including a plurality of time markers indicating audio events in the selected audio, and automatically controlling one or more lights according to the music feature file. In another embodiment, other approaches and systems are provided to improve a light show or to provide structures and processed files which can be used to improve a light show or provide other features.

20 Claims, 15 Drawing Sheets



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G10L 25/51 (2013.01)
H04R 1/40 (2006.01)
H04R 3/12 (2006.01)
H05B 47/155 (2020.01)

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 G10L 25/51; H04R 1/403; H04R 3/12;
 Y02B 20/40; G11B 31/00
 See application file for complete search history.

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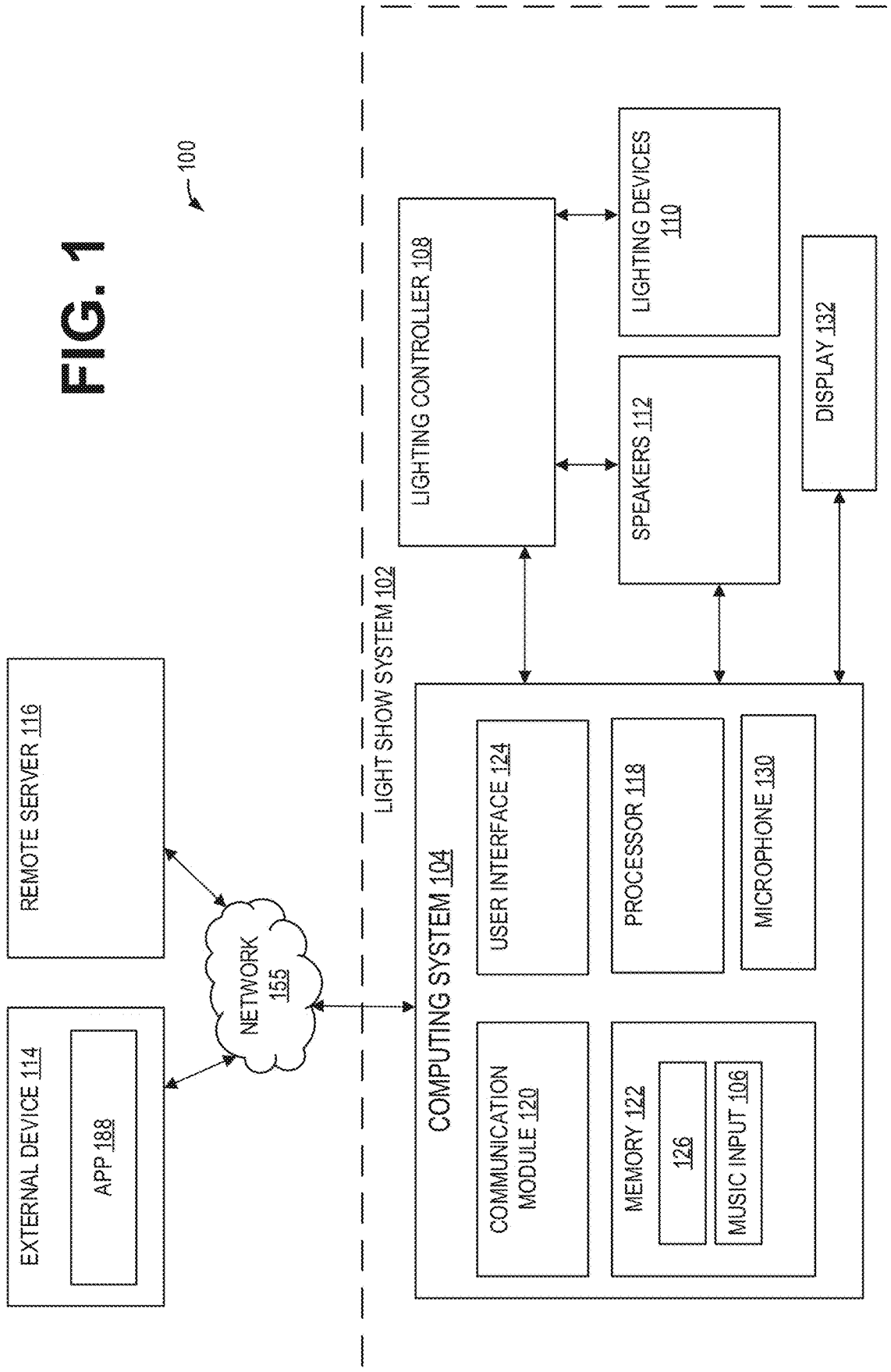
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FIG. 1



100

200

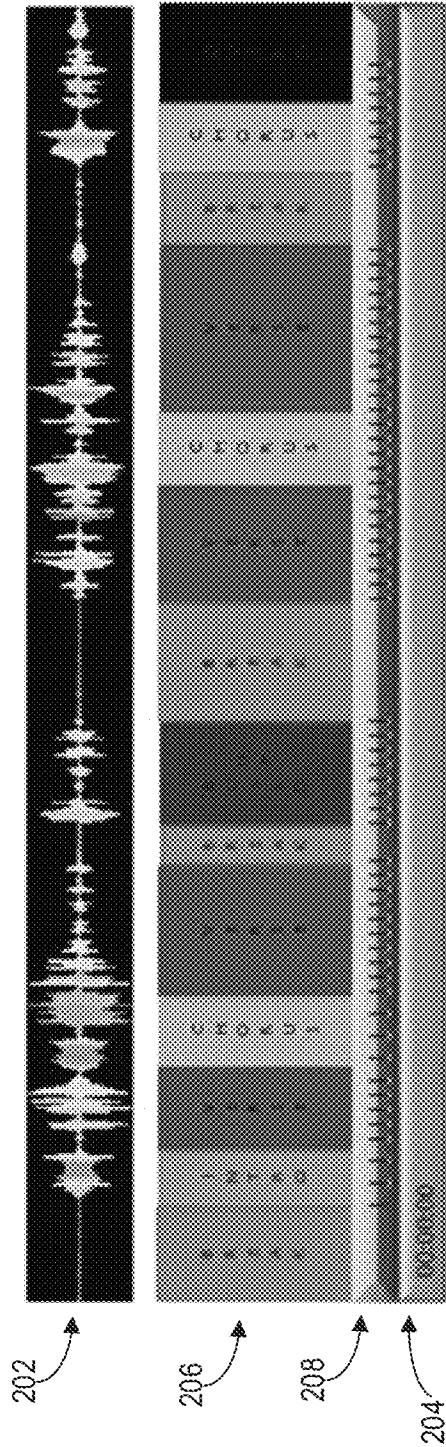


FIG. 2

300



FIG. 3A

330

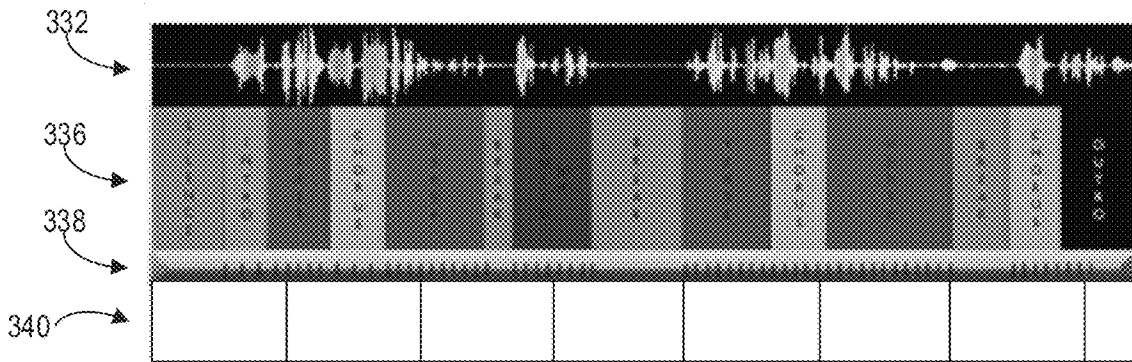


FIG. 3B

350

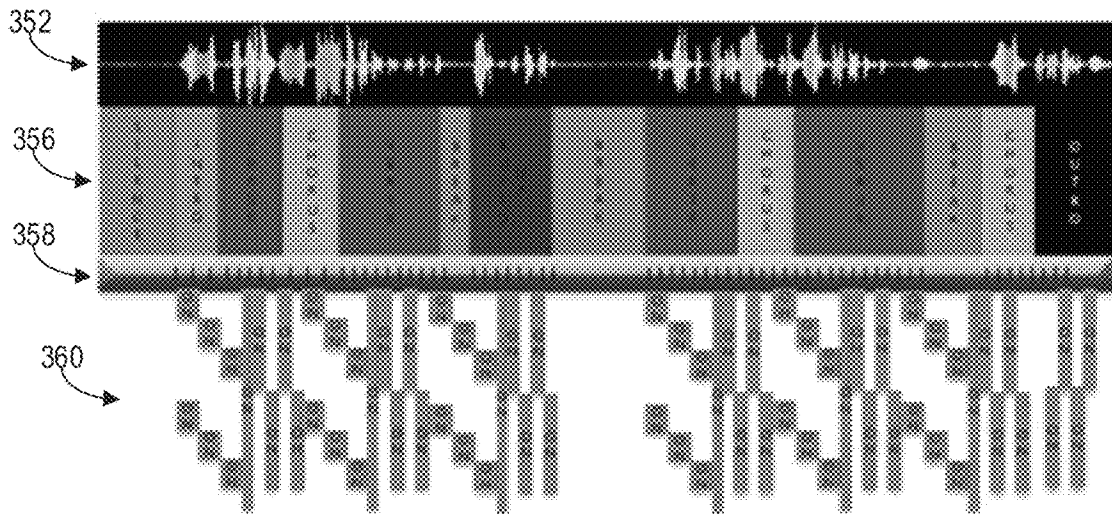


FIG. 3C

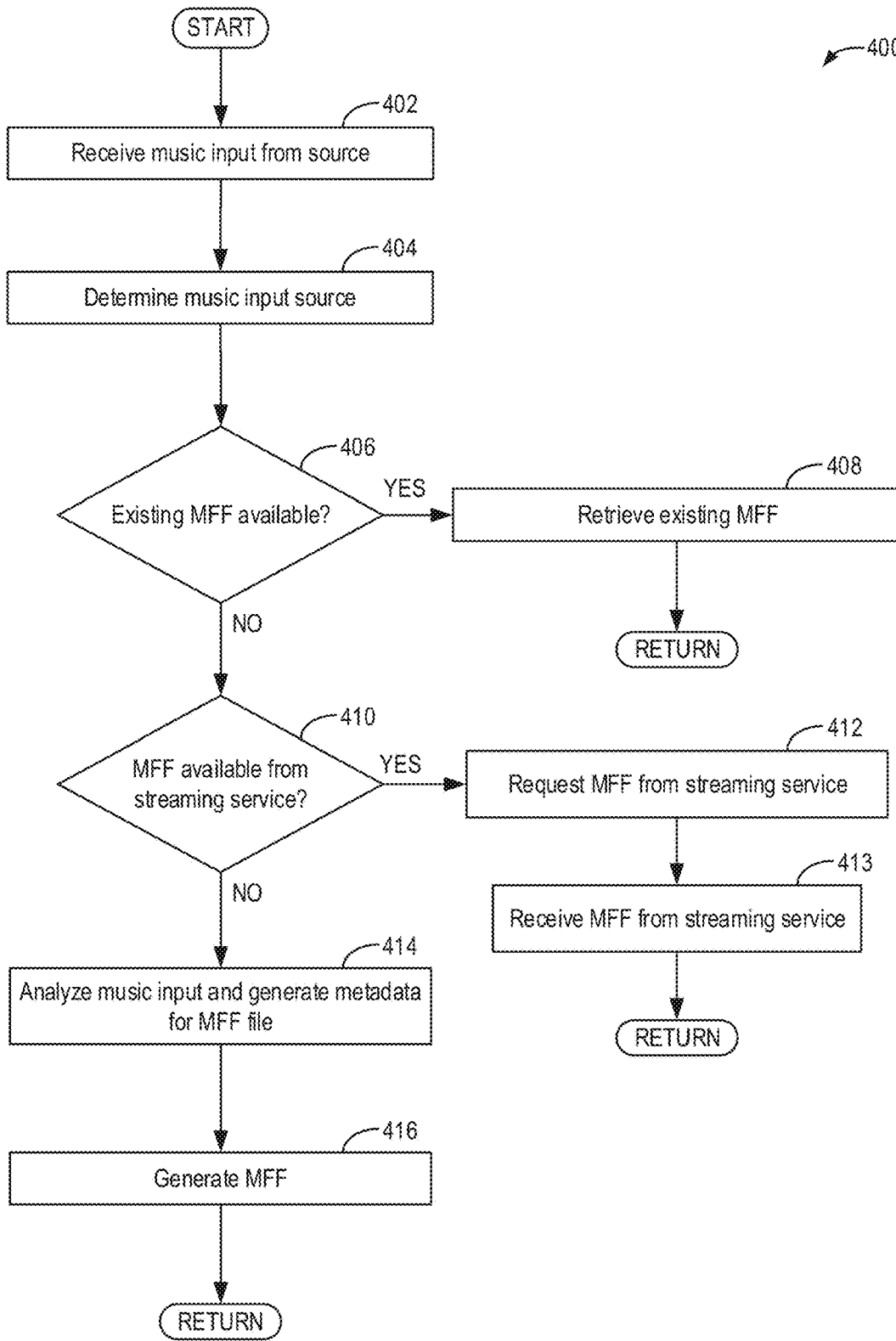


FIG. 4

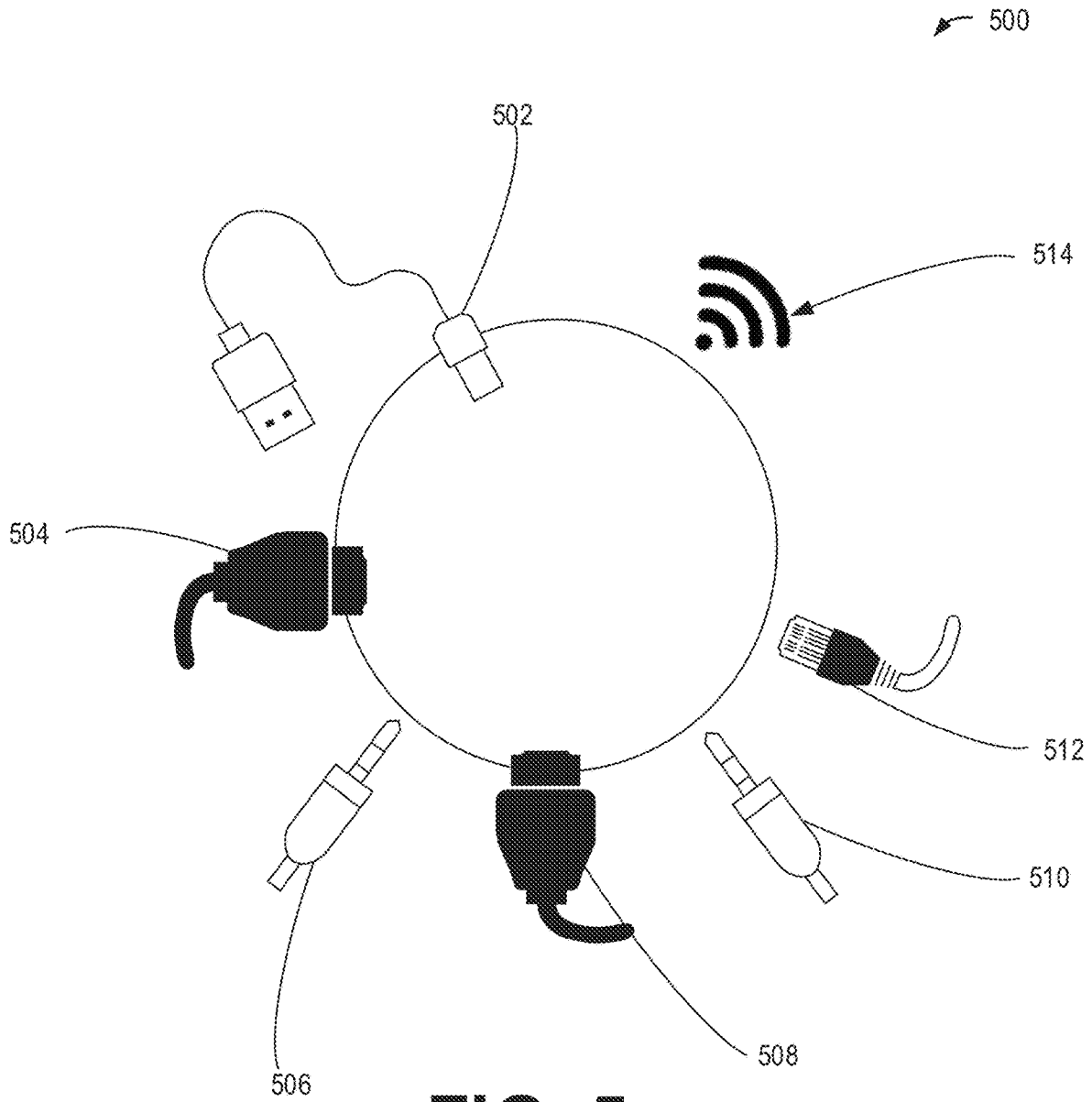


FIG. 5

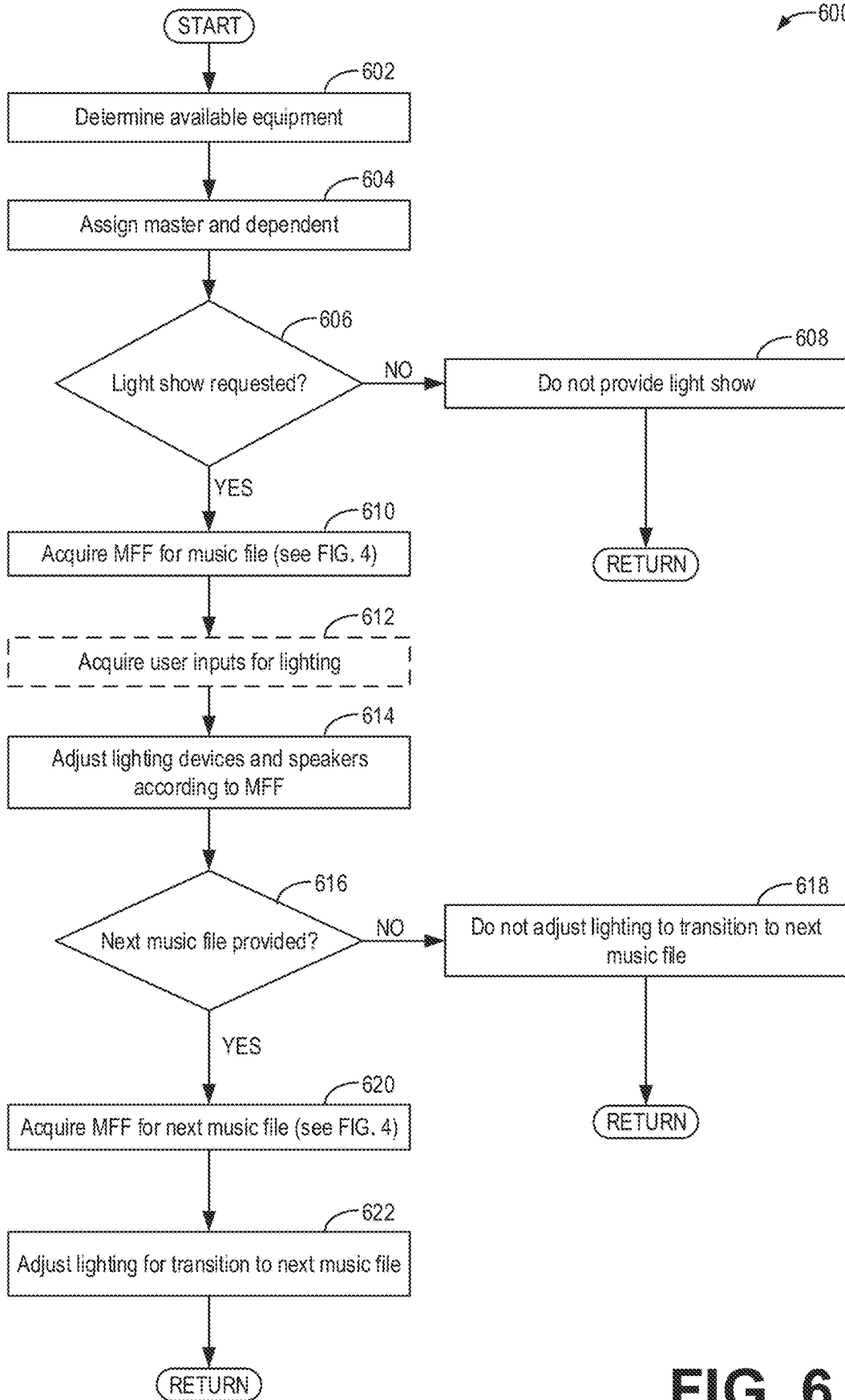


FIG. 6

700

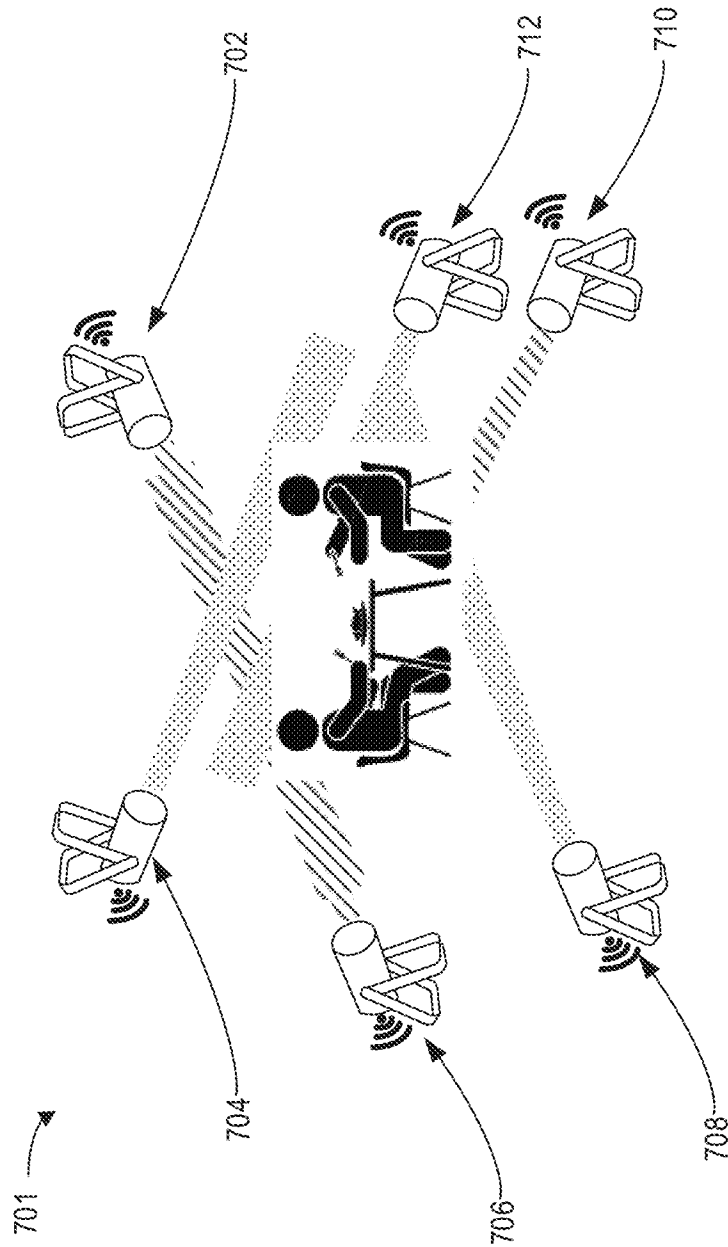


FIG. 7

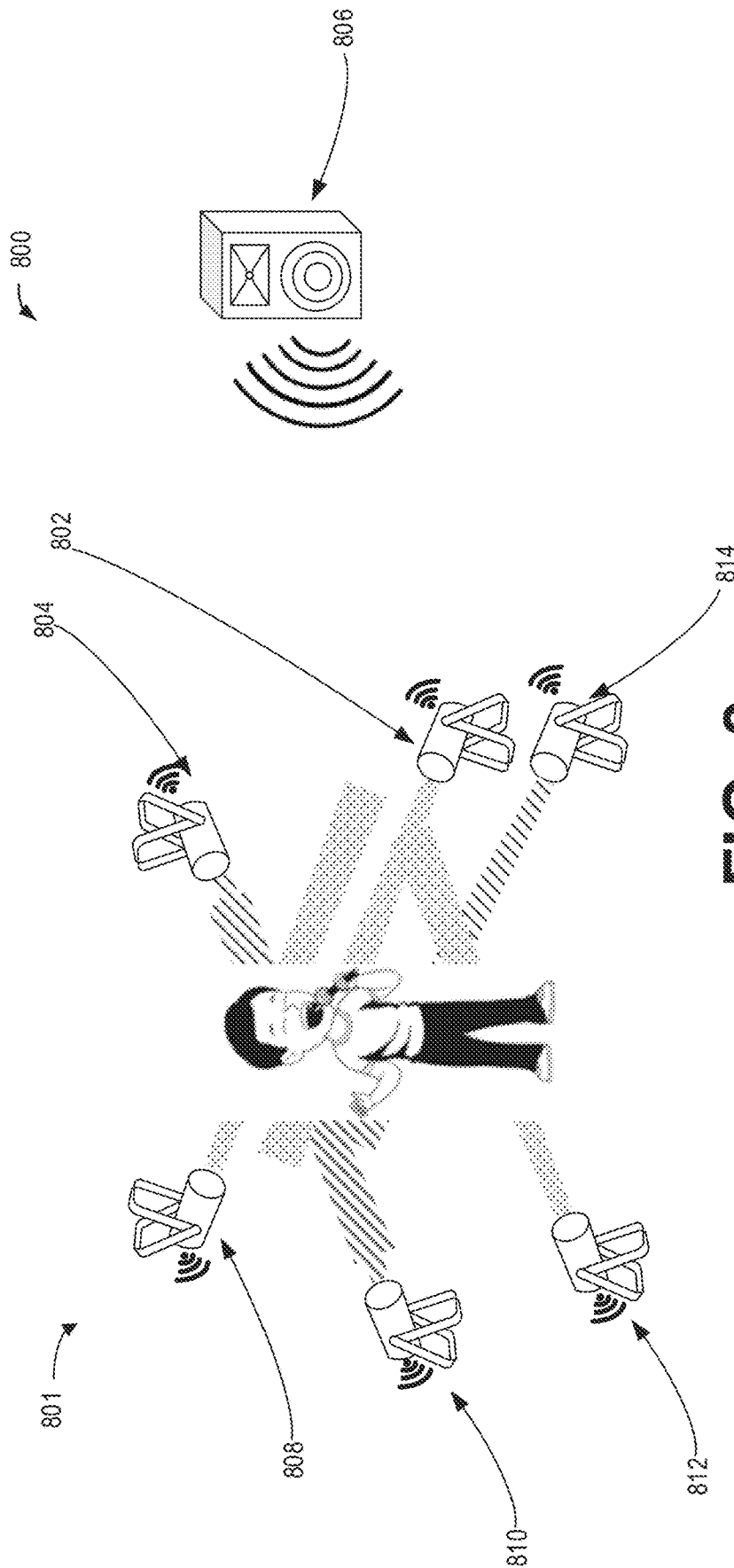


FIG. 8

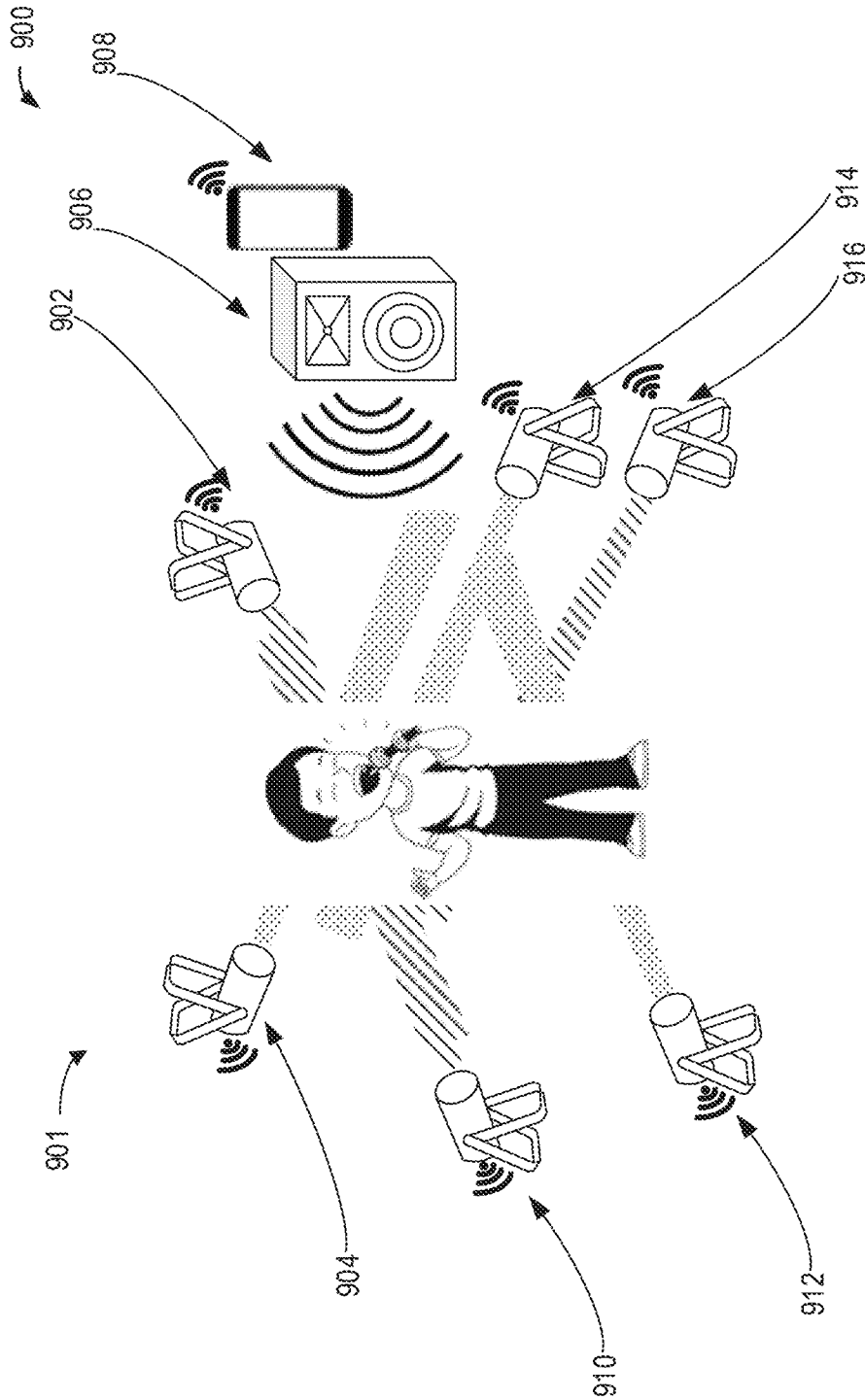


FIG. 9

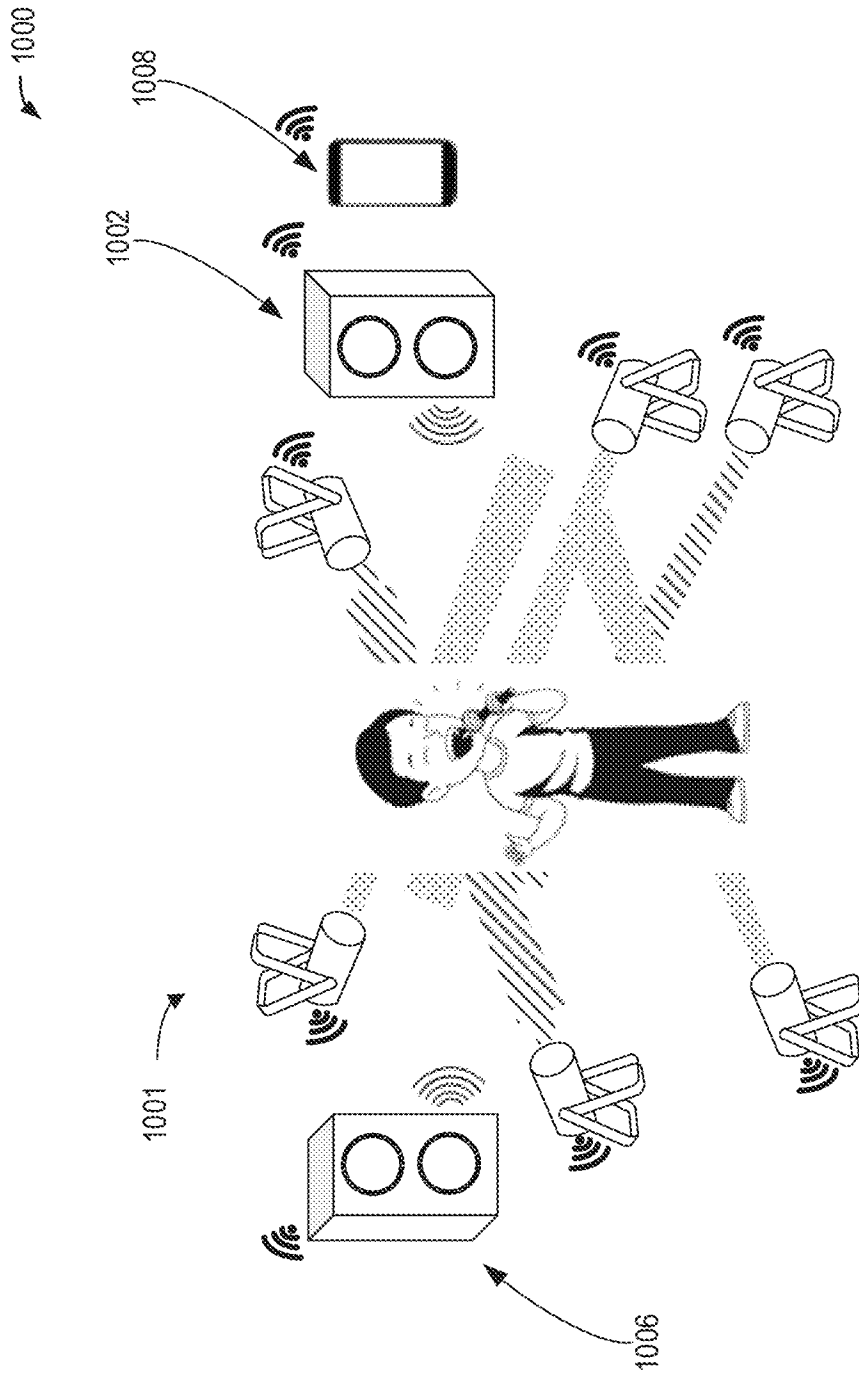


FIG. 10

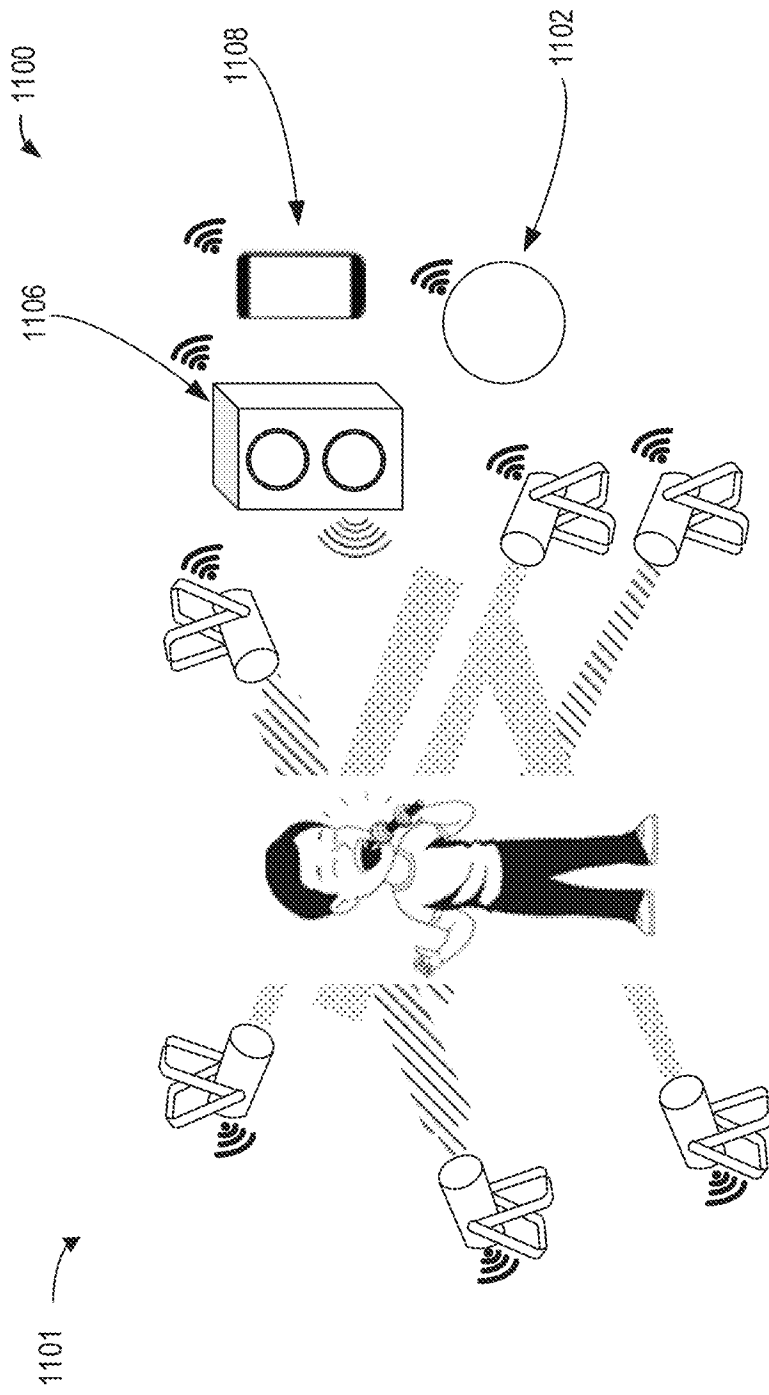


FIG. 11

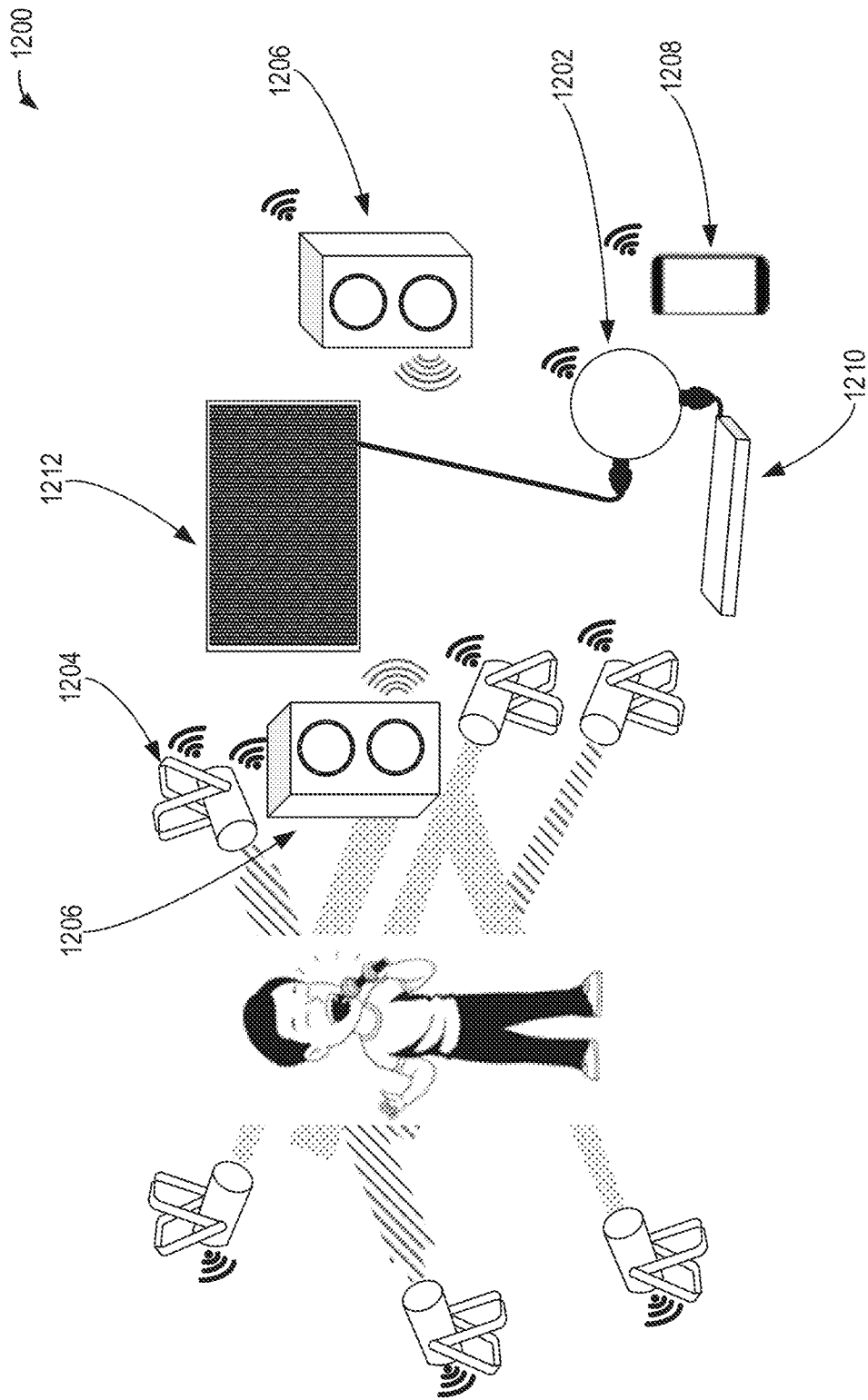


FIG. 12

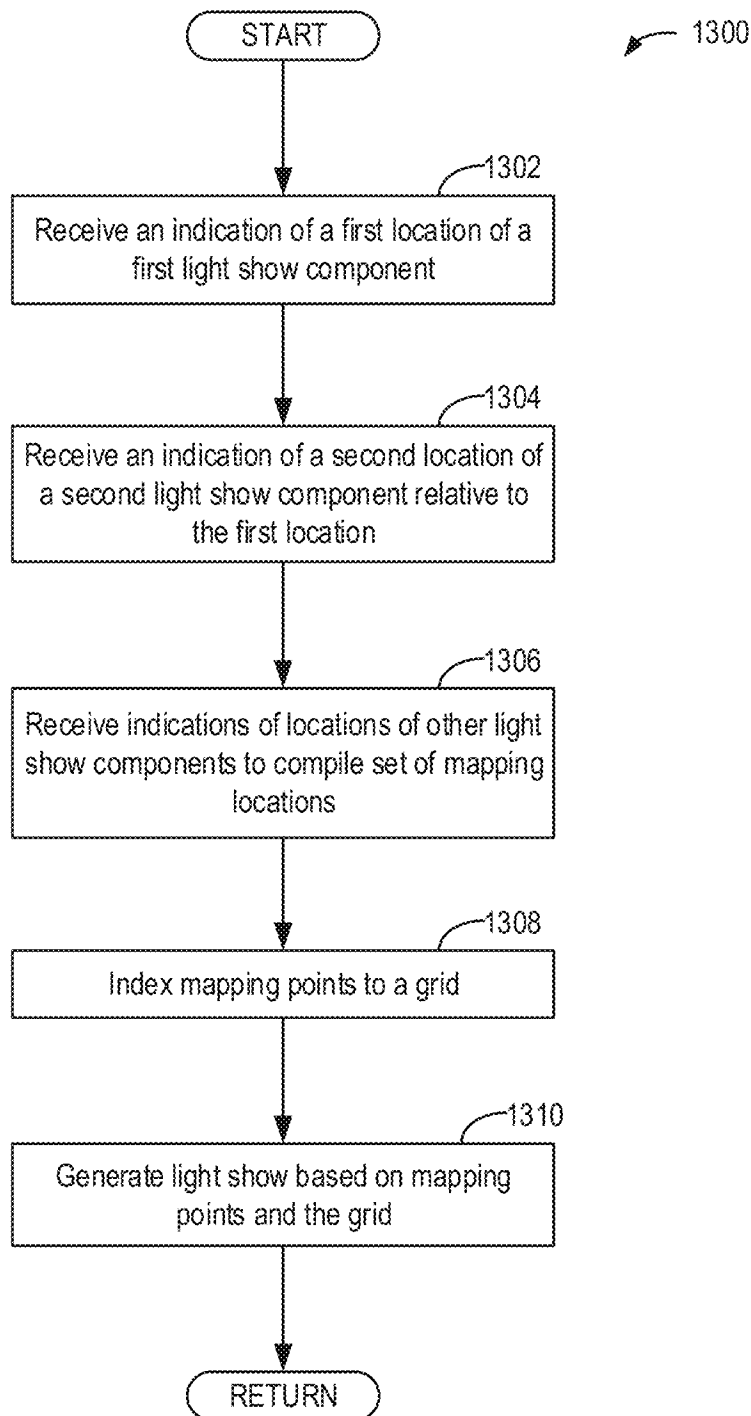


FIG. 13

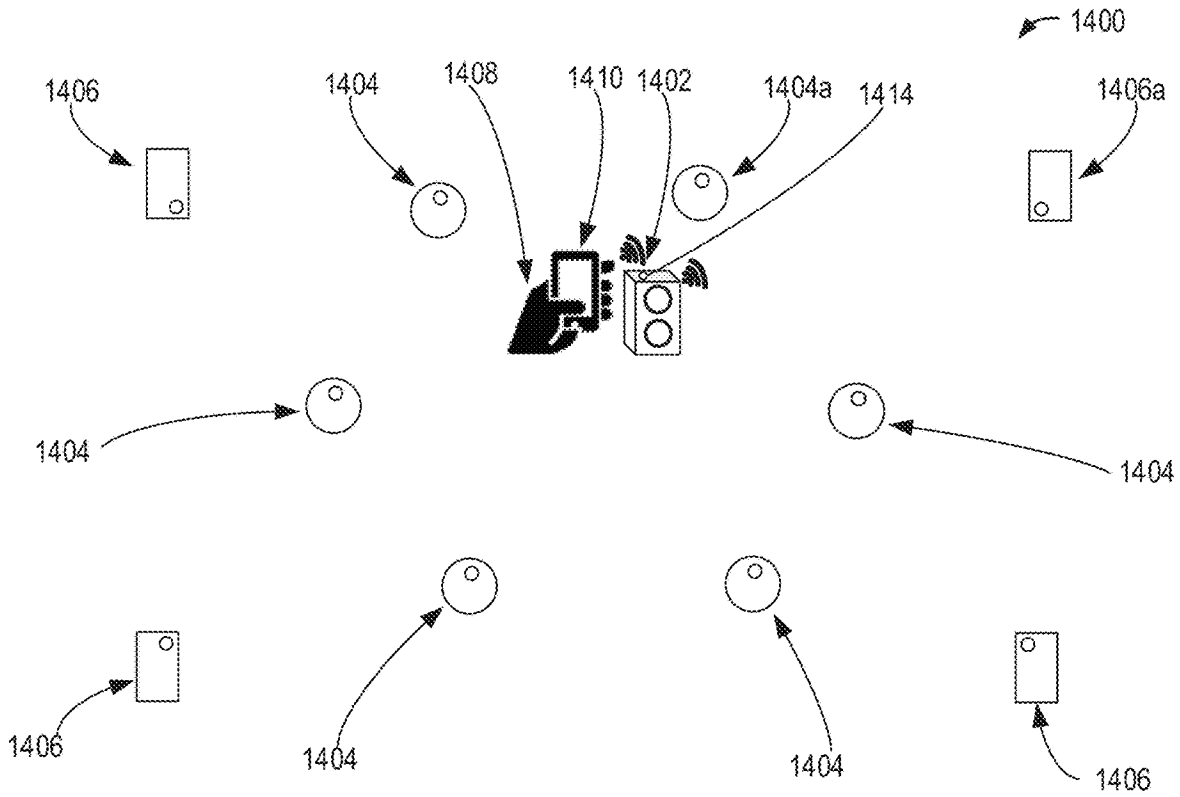


FIG. 14A

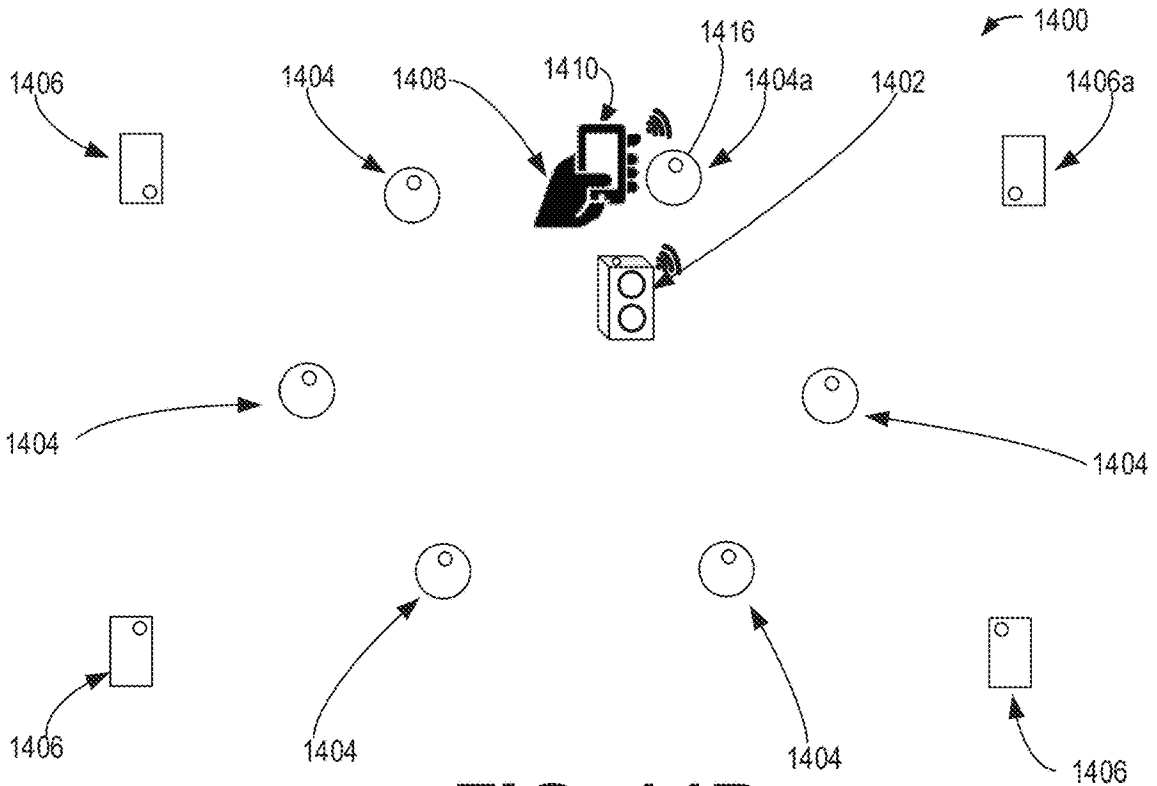
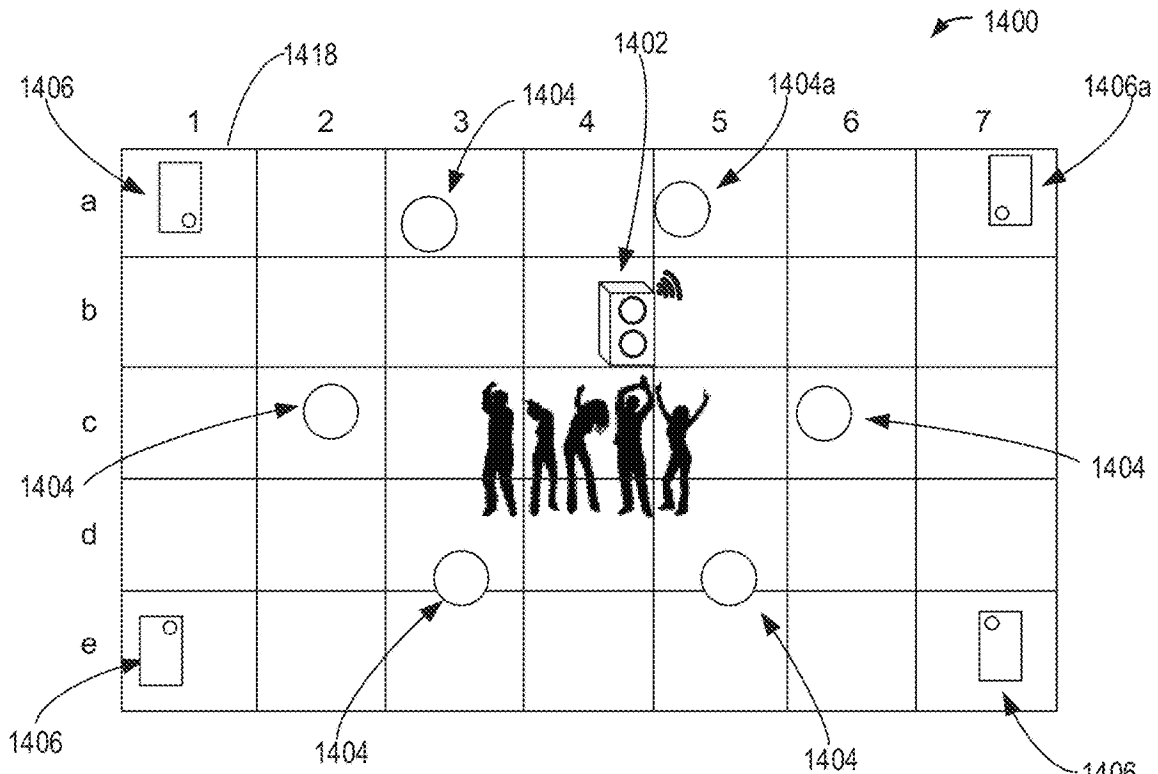
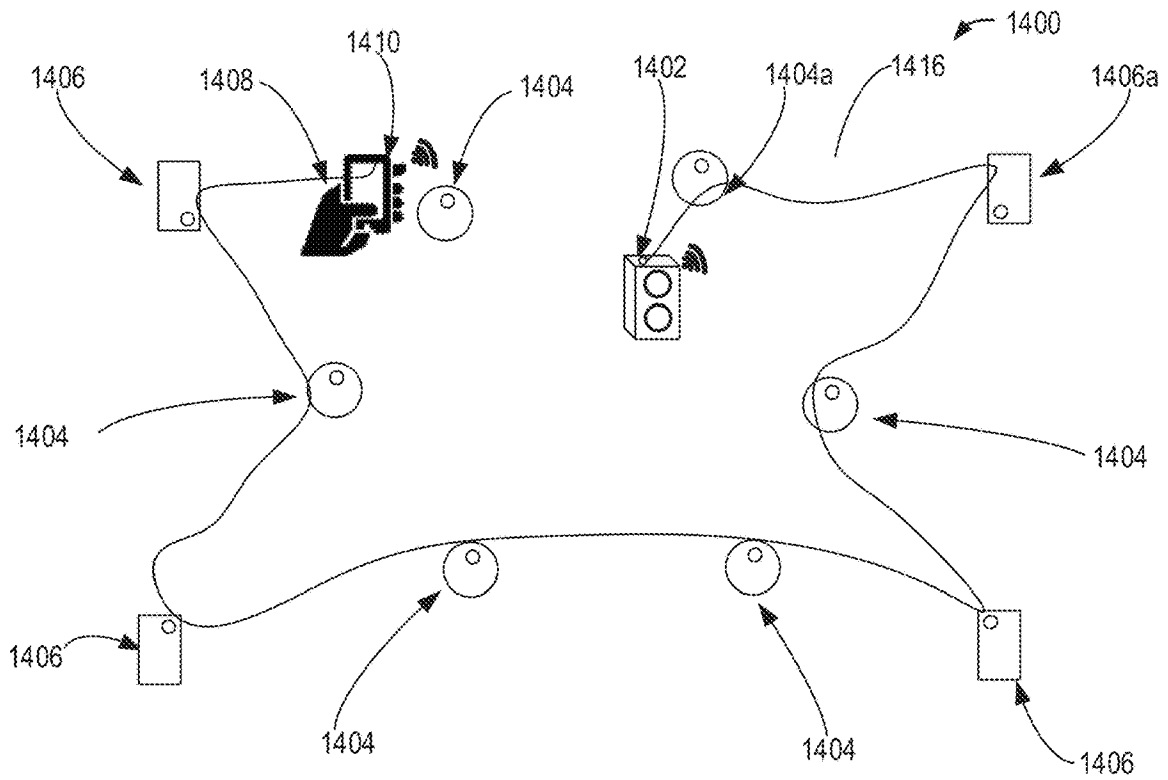


FIG. 14B



SYSTEMS AND METHODS FOR A MUSIC FEATURE FILE AND COORDINATED LIGHT SHOW

CROSS REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of U.S. patent application Ser. No. 17/122,966, filed Dec. 15, 2020, and entitled “SYSTEMS AND METHODS FOR A MUSIC FEATURE FILE AND COORDINATED LIGHT SHOW,” which claims priority to U.S. Provisional Application No. 62/951,863, entitled “SYSTEMS AND METHODS FOR A MUSIC FEATURE FILE AND COORDINATED LIGHT SHOW”, and filed on Dec. 20, 2019. The entire contents of the above-listed applications are hereby incorporated by reference for all purposes.

FIELD

The disclosure relates to methods for controlling one or more lights.

BACKGROUND AND SUMMARY

A “light show” may refer to a method of operating one or more lights, such as a spotlight, a laser, a strobe light, and so on, such that the visual effect of the lights complements one or more characteristics of a music file or a live musical performance. As an example, a light may be synchronized to respond to characteristics of a music file, such as a number of beats per minute (BPM), a time signature, a genre, a plurality of trigger beats marking musical transitions, and the like. Coordinated displays of music and light, as are provided by such light shows, may increase customer satisfaction in bars, night clubs, restaurants, and the like. Typically, a light show is controlled by a human operator, who may program sequences of adjustments to one or more lights corresponding to a pre-determined array of music files or may manually control the lights in real-time. In some examples, lights may be triggered by the beats in the music through various color presets, using a built in microphone.

In order to improve an automated light show synchronized with one or more music files, various embodiments are disclosed, one of which is for a music feature file (MFF), which may provide relevant metadata for a music file, and a lighting control apparatus. An example system for providing automated light shows, which may adjust one or more lights based on metadata in the MFF and optional user inputs, comprises a music feature file, one or more lights, and at least one computerized device, such as a laptop, a mobile phone, or a specialized lighting controller, the at least one computerized device communicatively coupled to, or integrated with, the one or more lights.

In one embodiment, a method comprises generating a music feature file based on selected audio, the music feature file comprising metadata for the selected audio including a plurality of time markers indicating audio events in the selected audio, and automatically controlling one or more lights according to the music feature file.

In another embodiment, other approaches and systems are provided to improve a light show or to provide structures and processed files which can be used to improve a light show or provide other features.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosure may be better understood from reading the following description of non-limiting embodiments, with reference to the attached drawings, wherein below:

FIG. 1 is a block diagram of a light show system in accordance with one or more embodiments of the present disclosure;

FIG. 2 shows a schematic depiction of a music feature file (MFF) protocol, according to at least one example of the present disclosure;

FIG. 3A shows a schematic depiction of a MFF protocol including packets sent at pre-determined intervals throughout a music file, according to at least one example of the present disclosure;

FIG. 3B shows a schematic depiction of another MFF protocol including a karaoke video, according to at least one example of the present disclosure;

FIG. 3C shows a schematic depiction of yet another MFF protocol including a light timing, according to at least one example of the present disclosure;

FIG. 4 shows a flow chart of a method according to at least one example of the present disclosure;

FIG. 5 shows a schematic view of an Integrated Light Show Hub according to at least one example of the present disclosure;

FIG. 6 shows a flow chart of a method for providing an automated light show according to at least one example of the present disclosure;

FIG. 7 shows an example configuration of a light show system according to at least one example of the present disclosure;

FIG. 8 shows another example configuration of a light show system including a speaker, according to at least one example of the present disclosure;

FIG. 9 shows another example configuration of a light show system including a speaker and a mobile device, according to at least one example of the present disclosure;

FIG. 10 shows another example configuration of a light show system including a plurality of speakers and a mobile device, according to at least one example of the present disclosure;

FIG. 11 shows an example configuration of a light show system including a plurality of speakers, a mobile device, and an Integrated Light Show Hub, according to at least one example of the present disclosure;

FIG. 12 shows an example configuration of a light show system including a plurality of speakers, a mobile device, a karaoke source, an Integrated Light Show Hub, and a display unit, according to at least one example of the present disclosure;

FIG. 13 shows a flow chart of a method for light mapping according to at least one example of the present disclosure;

FIG. 14A shows a first view of an example light show system during light mapping, according to at least one example of the present disclosure;

FIG. 14B shows a second view of the example light show system during light mapping, according to at least one example of the present disclosure;

FIG. 14C shows a third view of the example light show system during light mapping, according to at least one example of the present disclosure; and

FIG. 14D shows a view of an example light show system after light mapping, according to at least one example of the present disclosure.

DETAILED DESCRIPTION

FIG. 1 shows a block diagram of an example light show system **102** and related elements with which light show system **102** is in communication. Light show system **102**

may provide automated light shows based on metadata in a music feature file (MFF), as described in FIG. 2.

Light show system **102** may include a computing system **104**, a music file **106**, a lighting controller **108**, one or more lights **110**, and one or more speakers **112**. It is to be understood that any suitable number and/or combination of interconnects may be used to provide communication between various components of light show system **102** and related elements, including but not limited to Ethernet, Bluetooth, Wi-Fi, Controller-Area-Network (CAN), Media Oriented Systems Transport (MOST) buses, and so on. Further, light show system **102** may communicate with a network **155** wirelessly. The network **155**, which may be part of a server or other device, may communicate with an external device **114** and one or more remote servers **116**, via wireless and/or wired connections. In one example, external device **114** is a mobile phone, which may include an app **188**. App **188** may provide user inputs (e.g., user inputs regarding an automated light show) via a wireless connection with the computing system.

Computing system **104** may include one or more processors including a processor **118**, a communication module **120**, a user interface **124**, a non-volatile memory **122**, and a volatile memory **126**. Computing system **104** may be a standalone device (e.g., a laptop, a desktop computer, a mobile phone, and so on), while in other examples computing system **104** may be integrated with another component of light show system **102**. As an example, computing system **104** may be integrated with lighting controller **108**. As another example, computing system **104** may be integrated with a light or a speaker.

A non-volatile memory **122**, may be included in the computing system **104** to store data such as instructions executable by the processor **118** in non-volatile form. The non-volatile memory **122** may store application data to enable the computing system **104** to run an application for connecting to a cloud-based server and/or collecting information for transmission to the cloud-based server. The application may retrieve information gathered by input devices (e.g., a user interface **124**), devices in communication with the computing system (e.g., a mobile device connected via a Bluetooth link), and so on. Non-transitory storage devices, such as non-volatile memory **122** and/or volatile memory **126**, may store instructions and/or code that, when executed by the processor **118**, controls the computing system **104** to perform one or more of the actions described in the disclosure.

Processor **118** may execute programs stored in memory **122** of computing system **104**, control input/output, and interface with the other components of light show system **102**. Further, communication module **120** of computing system **104** may output data to the lighting controller **108**, the speakers **112**, and the lights **110**, while also receiving data input from other the music input **106**, the external devices **114**, the remote server **116**, and the lighting controller **108**.

User interface **124** of computing system **104** may enable the computing system to receive information from users, such as user preferences for light shows. In one example, a smartphone provides the user interface for light show system **102**, while in other examples, a dedicated touch-screen, keypad, or other input method allows a user to transmit preferences and/or commands to computing system **104**. The display may be a touch-screen display. Additionally or alternatively, the user interface may include an input hardware element, such as an input switch. The user interface may be electrically connected to the computing system **104**.

The controller may include a digital signal processor DSP with a static or adaptive algorithm solution, a graphic processing unit GPU, a system-on-a-chip SOC, and/or another integrated circuit IC. For example, the controller may include frequency impulse response (FIR) control filters and/or adaptive algorithm controls that alter or recalculate the FIR control filters. In other examples, displays may not provide a user interface, but may provide a televisual screen for projecting images (e.g., a music video synchronized to a music file).

In some embodiments, computing system **104** may be a mobile device. The mobile device may include a smart phone, a tablet, a laptop computer, a portable media player, and/or any suitable mobile computing system, and may be connected to other components of lighting system **102** via a communication link. The communication link may be wired (e.g., via Universal Serial Bus [USB], Mobile High-Definition Link [MHL], High-Definition Multimedia Interface [HDMI], and so on) or wireless (e.g., via BLUETOOTH, WI-FI, Near-Field Communication [NFC], and so on) and configured to provide two-way communication between the mobile device and the lighting system **102**. For example, the communication link may provide control and/or sensor signals from the mobile device to other components of the lighting system.

Computing system **104** may receive a music input **106**. In some examples, the music input may be a music file saved locally in memory non-volatile memory **122**, or may be provided via an AUX cable connection, a USB connection, a Bluetooth connection, and so on, from an external device **114**. As another example, the music input may be a streaming service, wherein a remote server **116** digitally streams a music file on command. In some examples, streaming a music file may include receiving a complete music file, while in other examples, streaming a music file may include receiving a plurality of packets from a remote server. In some embodiments, the computing system **104** may send the music input **106** to one or more of the plurality of speakers **112** in order to provide a synchronized audio-visual experience.

In some embodiments, the lighting controller **108** may adjust the lights **110** according to instructions received from the computing system **104**. However, in other embodiments, a lighting controller may not be included in lighting system **102**, and the computing system **104** may directly adjust one or more lights **110**. Further, in some embodiments the lighting controller **108** may transmit an audio signal to the speakers **112** according to instructions received from the computing system **104**, while in other embodiments, the computing system **104** may directly transmit an audio signal to the speakers **112**.

The speakers **112** may control a volume of audio output, a distribution of sound among the individual speakers of a plurality of speakers, an equalization of audio signals, and/or any other aspect of the audio output. In some examples, one or more of the speakers **112** may include a computing system, such as computing system **104**. Further, the lights **110** may include one or more lights, and may include a variety of light types, such as a spotlight, a globe light, a laser, a strobe light, and so on. In some examples, one or more of the lights may include a computing system, such as computing system **104**.

FIG. 2 shows a schematic representation of an example protocol governing a music feature file (MFF) **200**. As an example, MFF **200** may be a file containing characteristics of the music file, along with one or more time markers aligned with song events. The characteristics of the music

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file may include a time signature, a number of beats per minute (BPM), a musical key, a genre, and the like. Further, a timeline **204** may correspond to Music file **202**. In example MFF **200**, a plurality of song events, such as song events **206** may include a song beginning, a song end, a transition between verse and chorus, a transition between chorus and verse, a transition between verse and bridge, a climactic moment within the song (referred to herein as a “drop”), and so on. In one example, the song events **206** are categorized into a break, an intro, a verse, a chorus, and a build-up. It will be appreciated that other categorizations may be included and/or excluded from the song events **206**. MFF **200** may further include a plurality of trigger beats, such as trigger beats **208**, which may index song events **206** to timeline **204**. The MFF **200** may be supported multiple times during the track. In some embodiments, the MFF may be combined with the corresponding music file into a single file protocol, while in other embodiments, the MFF and the MP3 may be separate file protocols, and may be aligned by a separate controller. MFF **200** may be generated based on a music file, such as a corresponding music file **202**. In other examples, MFF **200** may be generated based on another type of music file, such as a WAV file or an MP4 file. Further, in some examples, MFF **200** may be generated in real-time, responsive to an analog or streaming music source.

FIG. **3A** shows schematic representation of another example MFF **300**. MFF **300** may be generated based on corresponding music file **302**. Further, MFF **300** comprises a plurality of packets **304**, each of the plurality of packets **304** including a complete set of metadata for music file **302**, such as a time signature, a BPM, a musical key, a genre, a plurality of song events, a plurality of trigger beats, a timeline, and an indication of location relative to music file **302**. With a MFF comprised of timed packets including the complete set of metadata for the music file, a light show system may use data from the entire music file after receiving one packet.

Next, FIG. **3B** shows a schematic representation of another example MFF **330**. The MFF **330** may be generated based on a corresponding music file **332**, and comprises a plurality of song events **336** and a plurality of trigger beats **338**. Further, the MFF **332** includes a karaoke video **340**, which may be aligned with the music file **332** such that a music video and song lyrics are timed to correspond with music file **332**. The karaoke video **340** may comprise one or more of lyrics, a background, a singer, or the like, wherein the karaoke video **340** is segmented based on one or more of the plurality of song events **336** and the plurality of trigger beats **338**.

Next, FIG. **3C** shows a schematic representation of another example MFF **350**. The MFF **350** may be generated based on a corresponding music file **352**, and comprises a plurality of song events **356** and a plurality of trigger beats **358**. Further, the MFF may include a timing **360** for specific light show devices (e.g., lights and speakers) corresponding to trigger beats and song events. In the embodiment of FIG. **3C**, MFF **350** may be a protocol combining the music file and the music feature file, which may improve processing time while providing a light show. The timing **360** may provide instructions for one or more lights, such as lights included in the light show system **102** of FIG. **1**. The timing **360** may be used to activate or deactivate one or more lights based on the plurality of song events **356** and/or the plurality of trigger beats **358**. In one example, as a tempo of the song increases (e.g., increased number of trigger beats within a predetermined duration), the timing **360** may signal to activate more lights and/or to increase an intensity of

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activated lights. Additionally or alternatively, as the tempo decreases, such as during a break in the plurality of song events **356**, the timing **360** may signal to deactivate the lights.

Turning now to FIG. **4**, it shows a flow chart of an example method **400** for acquiring a music feature file (MFF). The method **400** may be performed by a computing system, such as computing system **104** of FIG. **1**. Instructions stored on memory of the computing system **104** may be executed and enable the computing system to acquire the music feature file.

At **402**, method **400** includes receiving a music input. In some examples, the music input may be a music file stored in controller memory. In another example, the music input may be a music file stored on an external device, such as an external hard drive, a CD-ROM, a DVD, and so on. In yet another example, the music input may be a streaming service, which may provide the music file to the controller in real-time. In still another example, the music input may be an analog signal, provided via an AUX cable and/or a microphone. For example, an AUX cable connected to an independent music player (e.g., a record player, a radio, a portable music player, or the like) may deliver an analog music file to the controller in real time. As another example, the controller may receive an analog audio signal via a microphone, such as microphone **130** of FIG. **1**.

At **404**, method **400** includes determining a music input source. For example, the controller may determine whether the music file is available as a retrievable file in local memory or in an external device. The controller may further determine whether the music file is being provided by a streaming service. The controller may further determine whether the music file is being provided via an AUX cable and/or a microphone. For example, if the music input source is not a music streaming service, method **400** may determine that the music input source is a local file or an analog signal.

At **406**, method **400** includes determining whether an existing MFF is available for the music file. In one example, the MFF may have been generated and saved previously. As another example, the MFF may have been downloaded onto the computing system via another source. As yet another example, the MFF may be stored on the external device (e.g., an external hard drive, a personal computer, and so on), and may be available for download.

If method **400** determines that the MFF corresponding to the music input is available (“YES”), method **400** proceeds to **408**. At **408**, method **400** retrieves the existing MFF corresponding to the music input. After **408**, method **400** returns.

Referring again to **406**, if method **400** determines that an existing MFF is not available (“NO”), method **400** proceeds to **410**. At **410**, method **400** determines if the MFF is available from a streaming service. For example, if the music input source is a streaming service, the MFF may be available for download or for streaming via the streaming service.

If method **400** determines that the existing MFF is available from a streaming service (“YES”), method **400** proceeds to **412**. At **412**, method **400** requests the MFF from the streaming service. Continuing at **413**, method **400** receives the MFF from the streaming service. In some examples, the streaming service may transmit packets, such as packets **304** of FIG. **3A**, at pre-determined intervals during transmission of the music file. In another example, the streaming service may transmit a complete MFF, such as the MFF **200** of FIG. **2**, when computing device **104** begins streaming the music file. After **413**, method **400** returns.

Referring again to **410**, if method **400** determines that the MFF for the corresponding music input source is not available through a streaming service (“NO”), method **400** proceeds to **414**. At **414**, method **400** analyzes the music input and generates metadata for the MFF file. As an example, analyzing the music input may include determining song metadata such as a length, a number of BPM, a tempo, a genre, a plurality of song events, a mood, and a musical key. In one example, the music file is an MP3, and method **400** may input the MP3 file into one or more look-up tables, functions, or algorithms, which may output the song characteristics, for example. In one example, the music input is an analog music signal (e.g., via an AUX connection or a microphone), and method **400** may analyze the music file in real time to determine the song characteristics. For example, method **400** may input the analog music signal into one or more look-up tables, function, or algorithms, which may output the song characteristics. If the music input is an analog signal, the MFF protocol may include a plurality of discrete packets (e.g., such as the MFF protocol of FIG. 3A), and may update the song characteristics in real-time based on changes in the analog music signal.

At **416**, method **400** generates the MFF. The MFF may be generated by storing the song metadata determined at **412** according to a pre-determined protocol, such as the MFF protocol **200** of FIG. 2. In some examples, the MFF may be transmitted to a lighting controller, and additionally or alternatively be saved to controller memory. In other examples, the MFF may be transmitted to a remote server, such as remote servers **116** of FIG. 1. After **414**, method **400** returns.

FIG. 5 shows a view of an Integrated Light Show Hub **500**, which may provide an interface between a music source, a plurality of speakers, and a plurality of lights. In some examples, lighting controller **108** of FIG. 1 may be an Integrated Light Show Hub. The Integrated Light Show Hub **500** includes a computing system, and may communicate with other devices, such as the music source, a speaker, and a light, via one or more communication links. The communication link may be wired (e.g., via Universal Serial Bus [USB], Mobile High-Definition Link [MHL], High-Definition Multimedia Interface [HDMI], and so on) or wireless (e.g., via BLUETOOTH, WI-FI, Near-Field Communication [NFC], and so on) and configured to provide two-way communication between the Integrated Light Show Hub **500** and other devices. As shown in FIG. 5, Integrated Light Show Hub **500** includes a USB connector **502**, an outgoing HDMI connector **504**, an AUX cable **506**, an incoming HDMI connector **508**, a microphone connector **510**, a LIGHTNING connector **512**, and a WI-FI antenna **514**. In one example, the Integrated Light Show Hub may receive a MFF from a music source, such as via a wireless connection, and may adjust a signal to one or more lights and one or more speakers to provide a synchronized lighting show. In another example, the Integrated Light Show Hub may receive a music file, such as a MP3, from a music source, and may generate a MFF according to the method of FIG. 4. After generating a MFF, the Integrated Light Show Hub **500** may adjust a signal to one or more lights and to one or more speakers to provide a synchronized lighting show. In yet another example, the Integrated Light Show Hub may transmit the MFF to one or more lights and to one or more speakers, and may provide time synchronization between each device.

In the embodiment of FIG. 5, the Integrated Light Show Hub **500** may include beat, phrase, and key recognition, video color picking, and mapping information. Further, the

Integrated Light Show Hub **500** of FIG. 5 may include a processor capable of algorithmic processing, speech recognition, and control of a mobile application. For example, the Integrated Light Show Hub **500** may receive a music file via an analog music signal (e.g., from the AUX connector **506**), and may provide a light show based on the analog music signal in real-time. The Integrated Light Show Hub **500** may apply predictive learning algorithms to the analog music signal to determine characteristics of the music file, such as a number of BPM and a genre. The Integrated Light Show Hub may transmit packets to one or more connected devices at a pre-determined interval, such as every 20 milliseconds (ms), for example, with an average latency of 20 ms, for example. Further, the Integrated Light Show Hub may receive packets from one or more connected devices at a pre-determined interval, such as every 5 seconds, for example.

Next, FIG. 6 shows an example method for providing an automated light show based on a music input and a corresponding music feature file (MFF). The method **600** may be performed by a light show system such as light show system **102** of FIG. 1, which may include a computing system such as computing system **104**. The light show system may further include a lighting controller, which may be an Integrated Light Show Hub, such as the Integrated Light Show Hub show in FIG. 5. In examples including an Integrated Light Show Hub, the computing system may be integrated with the Integrated Light Show Hub. In examples not including an Integrated Light Show Hub, the computing system may be integrated into the lighting controller, a mobile device, a light, or another external device.

At **602**, method **600** includes determining available equipment included in the light show system. For example, a light show system may include a plurality of speakers and a plurality of lights. In some examples, a light show system may further include a monitor for a karaoke video, a mobile device, a lighting controller (e.g., an Integrated Light Show Hub), and so on. Further, method **600** may determine the characteristics of the available equipment, such as a type of light (e.g., strobe, laser, spotlight, and so on), a connection method (e.g., wired, Bluetooth, WiFi, and so on), a color-change ability, a frequency, a location, pan and tilt area and an intensity.

At **604**, method **600** includes assigning a master device and one or more dependent devices (e.g., slave devices). For example, if an Integrated Light Show Hub is detected at **602**, the Integrated Light Show Hub may be designated as the master device. If an Integrated Light Show Hub is not detected at **602**, the first device including a processor to respond may be designated as the master device. All devices in the light show system not designated as the master device may be designated as dependent devices. Thus, method **600** may be executed by a controller included in a speaker, an Integrated Light Show Hub, or a light. However, in some examples, a separate computing device may be designated the master, and may execute method **600**.

At **606**, method **600** determines whether a light show is requested for a provided music file. For example, a user input may trigger a request for a light show. For example, a user may press a key or button in a user-interface connected to the lighting system, and may request a light show. In some embodiments, selecting a music file may trigger a request for a light show. For example, a user input may trigger a first music file selection, and a light show may be automatically provided for a selected music file.

If method **600** determines that a light show is not requested (“NO”), method **600** proceeds to **608**. At **608**,

method 600 does not provide a light show. For example, the light show system may not acquire a MFF for a corresponding music file, may not adjust a light according to the MFF, and may not transmit a music signal to a speaker. After 608, method 600 returns.

However, referring again to 606, if method 600 determines that a light show is requested (“YES”), method 600 proceeds to 610. At 610, method 600 acquires a MFF for the first music file. For example, method 600 may acquire the MFF for the first music file according to the method 400 described hereinabove.

Continuing at 612, method 600 optionally acquires user inputs for lighting. In some embodiments, a user may modify a number of light show pre-sets, which may change the method by which lights are adjusted. For example, a user may enter a color preference by pressing a button on a user interface, which may modify an algorithm for providing the light show. A user may further input a number of lights, a desired efficiency, a desired pulsing, and the like. For example, if the user inputs to a relatively high desired efficiency, then the light show may reduce a light intensity and number of lights activated compared to a light show with a lower desired efficiency.

Continuing at 614, method 600 adjusts one or more lights and/or speakers according to the metadata in the MFF for the first music file. If a user input was acquired at 612, method 600 may also adjust one or more lights based on the user input. In some examples, the master device may directly adjust the one or more lights and/or speakers. In other examples, if one or more dependent devices includes a computing system, the master device may transmit a protocol for adjustment, referred to herein as a “lighting feature file” (LFF), to the one or more dependent devices. Based on metadata in the LFF, a controller of each dependent device with a computing system may make a series of adjustments. Thus, in some examples, adjusting one or more lights and/or speakers according to the metadata in the MFF for the first file at 614 may include transmitting a LFF to one or more dependent devices. The LFF may include general instructions for adjusting a light show device, a position of the dependent device relative to the master device, and so on. Additionally or alternatively, colors, pulsations, brightness, contrast, intensity, and the like may be adjusted. Intensity may correspond to a color, such that a dark red when may be more intense than a light red. Brightness may refer to a visual sensation of a light. For example, a yellow light may be brighter than a purple light. In one example, the yellow light illuminates a greater area than the purple light. Contrast may refer to an amount of blending between light and dark areas. For example, low contrast may include a greater amount of blending between light and dark areas relative to high contrast, which may more clearly define light and dark areas.

At 616, method 600 determines whether a second music file is provided. For example, a user may request a light show that accompanies a sequence of music files. A user may provide a list of files before beginning the light show, or may add a new music file to the sequence of music files while the first music file is playing.

If the method determines that the second music file is not provided (“NO”), method 600 proceeds to 618 and includes not adjusting lighting to transition to the next music file. For example, method 600 may not adjust a tempo or color of lights to provide a transition between the first music file and the second music file. Method 600 then returns.

However, referring again to 616, if method 600 determines that a next music file is provided (“YES”), method

600 proceeds to 620 and acquires the MFF for the next music file. For example, method 600 may acquire the MFF for the next music file according to the method 400 described hereinabove with regard to FIG. 4.

After acquiring the MFF for the next music file, method 600 continues to 622. At 622, method 600 adjusts one or more lights to provide a transition between the first music file and the second music file. For example, the method may input a MFF corresponding to the first music file and a MFF corresponding to the second music file into one or more look-up tables, algorithms, or functions, which may output one or more adjustments for transitioning between the first music file and the second music file. In some embodiments, the method may include fading out the first music file on the speakers, and fading in the second music file on the speakers, in order to provide a more satisfying transition. After 622, method 600 returns.

FIG. 7 is a view of a light show system 700. Light show system 700 includes a plurality of lights 701, including a master light 702 and dependent lights 704, 706, 708, 710, 712. In the example of FIG. 7, the master light 702 may broadcast an automated light show. The automated light show may be a pre-determined sequence of adjustments to the master light 702 and the dependent lights, for example. In another example, the automated light show may be generated based on one or more music feature files.

The plurality of lights 701 are depicted as emitting differently colored light beams. In one example, a striped beam represents a first color and the dotted beam represents a second color, different than the first color. It will be appreciated that less than or greater than two color may be emitted by the plurality of lights 701 based on the acquired MFF.

FIG. 8 is a view of a light show system 800, including a plurality of lights 801 and an audio source 806. In one example, the audio source 806 is a speaker 806. The plurality of lights 801 includes a master light 802, and dependent lights 804, 808, 810, 812, and 814. In the example of FIG. 8, the master light 802 may broadcast an automated light show separately from the speaker 806. That is to say, the speaker 806 and the plurality of lights 801 may not be in communication. However, each of the speaker 806 and the plurality of lights 801 are instructed to play an identical audio file, wherein the master light 802 signals to the dependent lights 804, 808, 810, 812, and 814 to play a light show in conjunction with the MFF while the speaker 806 plays an audio file. In one example, audio of the audio file is identical to audio of the MFF.

FIG. 9 is a view of a light show system 900, including a plurality of lights 901, a speaker 906, and a mobile device 908. The plurality of lights 901 includes a master light 902, and dependent lights 904, 910, 912, 914, and 916. The mobile device 908 may include a smart phone, a tablet, a laptop computer, a portable media player, and/or any suitable mobile computing system. The mobile device 908 may be connected to the master light 902 and the speaker 906 via a communication link. The communication link may be wired or wireless, and may be configured to provide two-way communication between the mobile device 908, the master light 902, and the speaker 906. In the example of FIG. 9, the mobile device 908 may transmit a MFF and/or a series of lighting adjustments to the master light 902, and may further transmit a music file to the speaker 906. The master light 902 may broadcast an automated light show to the plurality of dependent lights 904 based on one or more music files and/or MFFs provided by the mobile device 908, and may be calibrated to correspond to the music file as

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transmitted by the speaker **906**. Further, a user may adjust parameters of the automated light show via mobile device **908**. Similar to the example of FIG. **8**, the speaker **906** is not in communication with the mobile device **908** and/or the plurality of lights **901**. As such, the speaker **906** does not include wireless communication abilities.

FIG. **10** is a view of a light show system **1000**, including a master speaker **1002**, a plurality of lights **1001**, a dependent speaker **1006**, and a mobile device **1008**. The mobile device **1008** may include a smart phone, a tablet, a laptop computer, a portable media player, and/or any suitable mobile computing system. The mobile device **1008** may be connected to the master speaker **1002** and the plurality of lights **1001** via a communication link. The communication link may be wired or wireless, and may be configured to provide two-way communication between the mobile device **1008**, the master speaker **1002**, and the dependent speakers **1006**. In the example of FIG. **10**, the mobile device **1008** may transmit a MFF and/or a series of lighting adjustments to the master speaker **1002**, and may further transmit a music file to the master speaker **1002**. The master speaker **1002** may broadcast an automated light show to the plurality of dependent lights **1001** based on one or more music files and/or MFFs provided by the mobile device **1008**, and may further broadcast a music file to the dependent speakers **1006**. Further, a user may adjust parameters of the automated light show via mobile device **1008**.

The master speaker **1002** comprises wireless communication capabilities, such as Wi-Fi, in order to communicate with the dependent speaker **1006** and the plurality of lights **1001**. The master speaker **1002** may relay instructions from the mobile device **1008** with regard to a light show corresponding to a MFF to the plurality of lights **1001** while relaying an audio file to the dependent speaker **1006**. Additionally or alternatively, the master speaker **1002** and the dependent speaker **1006** may comprise one or more lighting fixtures configured to provide further light sources for the light show.

FIG. **11** is a view of a light show system **1100**, including an Integrated Light Show Hub **1102**, a plurality of dependent lights **1101**, a dependent speaker **1106**, and a mobile device **1108**. In such a light show system, the Integrated Light Show Hub **1102** may be designated as the master. The mobile device **1108** may include a smart phone, a tablet, a laptop computer, a portable media player, and/or any suitable mobile computing system. The Integrated Light Show Hub **1102** may be connected to the mobile device **1108**, the dependent speakers **1106**, and the dependent lights **1101** via a communication link. The communication link may be wired or wireless, and configured to provide two-way communication between the Integrated Light Show Hub **1102**, the dependent lights **1101**, the dependent speakers **1106**, and the mobile device **1108**. In the example of FIG. **11**, the mobile device **1108** may transmit a MFF and/or a music file to the Integrated Light Show Hub **1102**. The Integrated Light Show Hub **1102** may broadcast an automated light show to the plurality of dependent lights **1101** based on one or more music files and/or MFFs provided by the mobile device **1108**, and may further broadcast a music file to the dependent speakers **1106**. Further, a user may adjust parameters of the automated light show via mobile device **1108**. As another example, the Integrated Light Show Hub may receive a music signal via a microphone, and may generate a light show synchronized to the music signal in real-time.

FIG. **12** shows a view of a light show system **1200**, including an Integrated Light Show Hub **1202**, a plurality of dependent lights **1204**, a plurality of dependent speakers

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1206, a mobile device **1208**, a music source **1210**, and a graphical display unit **1212**. In the example of FIG. **12**, the Integrated Light Show Hub **1202** may receive a music signal and a video signal from the music source **1210** via a HDMI communication link, and may further receive one or more user inputs from the mobile device **1208** via a communication link (e.g., a wired communication link or a wireless communication link). Further, the Integrated Light Show Hub **1202** may transmit a video signal to the graphical display unit **1212** via a HDMI communication link. Based on a music file from the music source **1210**, the Integrated Light Show Hub may receive, download, or generate a MFF for providing a light show corresponding to the music file. For example, the Integrated Light Show Hub may generate the MFF according to the method **400** of FIG. **4**. Further still, the Integrated Light Show Hub **1202** may transmit a sequence of lighting adjustments to the dependent lights **1204**, and may transmit an audio signal to the dependent speakers **1206**, according to the method described hereinabove with regard to FIG. **6**. Thus, the Integrated Light Show Hub **1202** may broadcast an automated light show to the plurality of dependent lights **1204** based on one or more music files and/or MFFs provided by the mobile device **1208**, and may further broadcast a music file to the dependent speakers **1206**. Further, a user may adjust parameters of the automated light show via mobile device **1208**.

According to the present disclosure, a light show may be improved based on a mapping of relative locations of light show components (e.g., lights, speakers, lighting controllers, mobile devices, and so on). For example, utilizing features in a BLUETOOTH protocol, such as an Angle of Arrival (AoA) and an Angle of Departure (AoD), it is possible to perform a two-dimensional and/or three-dimensional mapping of an enclosed space including a plurality of lights and speakers. As another example, mobile devices, such as smartphones, may include integrated motion sensors, such as microelectromechanical systems (e.g., MEMS), which may provide fast and reliable signals for characterizing motion. In particular, sensor fusion, which combines signals from a gyroscope, an accelerometer, and a compass, may accurately determine the position of a smartphone over time. A filtering algorithm, such as an algorithm including Kalman filtering, may be applied to improve an accuracy of the locations of the plurality of light and sound devices. In one example, a Zero Velocity Update (ZUPT) algorithm may be applied, for example.

FIG. **12** further illustrates the Integrated Light Show Hub **1202** being connected to a karaoke player **1212**. In one example, the karaoke player **1212** may include a display device, such as a television, a projector, a monitor, or other display device. Additionally or alternatively, a media player **1210** may be connected to the Integrated Light Show Hub **1202**. The media player **1210** may be configured to read CDs, videotapes, cassette tapes, DVDs, Blu-ray, and the like. The media player **1210** may transmit song data to the Integrated Light Show Hub **1202**, wherein a MFF may be generated via the method of FIG. **4** and transmitted to one or more of the plurality of lights **1204** and the speakers **1206**. In this way, the Integrated Light Show Hub **1202** may receive inputs from a plurality of devices and send outputs to a plurality of lights and speakers.

In one example, a user may use the mobile device **1208** of the Integrated Light Show Hub **1202** to adjust one or more settings of the light show, including color, sound, intensity, brightness, contrast, and the like.

FIG. **13** shows an example method **1300** for mapping locations of light show components, and adjusting an auto-

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mated light show based on the locations of the light show components. By indexing locations of the light show components to locations of a mobile device including sensor fusion, a controller may build a virtual map of a light show system, including relative locations of a plurality of light show components. Based on the relative locations of the light show components, an automated light show may be adjusted to increase customer satisfaction. Method 1300 may be performed by a controller equipped with a plurality of sensors (e.g., an accelerometer, a gyroscope, a compass, GPS, and the like), such as a mobile device (e.g., a smartphone), which may be communicatively linked with one or more light show device (e.g., a “smart” speaker, an Integrated Light Show Hub, a light, a lighting controller, and so on). Further, each light show component may include a button. When the button of a component is depressed, the button may establish a communication link with the controller, and may further signal that a location of the component corresponds with a location of the mobile device. For example, when a button on a strobe-light is pressed, a controller may determine that a location of the mobile device corresponds to a location of the strobe-light. Note that method 1300 may be described with reference to FIGS. 14A-14D, which show views of a light show system during a light show component mapping. The light show systems of FIGS. 14A-14D are identical, and will be numbered identically. Components introduced in FIG. 14A will not be reintroduced in FIGS. 14B-14D.

At 1302, method 1300 includes receiving an indication of a first location of a first light show component. In one non-limiting example, a user may wirelessly connect via a mobile device to the first light show component and depress a button on the first light show component, while in physical proximity to the first light show component. Depressing the button on the first light show component may cause the wireless device to transmit its location to the controller. Responsive to receiving the location of the first light show component, the controller may establish a first mapping point. In the example embodiment of FIG. 14A, light show system 1400 includes a speaker 1402, a plurality of globe lights 1404, including a first globe light 1404a, and a plurality of spotlights 1406. A user 1408 and a smartphone 1410 are in physical proximity to the speaker 1402, which may be the first light show component, and may include a first button 1414. Speaker 1402 may be a “smart” device including at least one computing system, and may connect to other light show components and the smartphone 1410 via a communication link (e.g., a wireless or wired connection).

At 1304, method 1300 includes receiving an indication of a second location of a second light show component relative to the first location. In one non-limiting example, the user may wirelessly connect to the first light show component and depress a button on a second light show component, while in physical proximity to the second light show component. Depressing the button on the second light show component may cause the wireless device to transmit its location to the controller. Responsive to receiving the location of the second light show component, the controller may establish a first mapping point. Further, using sensor fusion (e.g., integrated data from a gyroscope, an accelerometer, and a compass), method 1300 may determine a position of the second light show component relative to the first mapping point. The position of the second light show component relative to the first mapping point may be the second mapping point. An example light show system configuration during 1304 is shown graphically in FIG. 14B. In FIG. 14B, the user 1408, with the smartphone 1410, are in physical

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proximity to a first globe light 1404a, which may be the second light show component. Further, the first globe light 1404a includes a second button 1416.

At 1306, method 1300 includes receiving indications of locations of other light show components to compile a set of mapping locations. Thus, method 1300 may assemble a set of mapping points corresponding to the location of each light show component relative to the first light show component. As shown in FIG. 14C, a set of mapping points is determined based on the relative locations of each light show component received as the user 1408 interacts with each component while traversing a path 1416 around the light show system 1400. The set of mapping points may be stored in a non-volatile memory location in the controller, or may be stored in a remote server. For example, the computing system of the speaker 1402 may transmit the set of mapping points to smartphone 1410, which may store the mapping points in local memory, or may transmit the mapping points to a remote server for processing.

At 1308, method 1300 includes indexing the set of mapping points corresponding to the location of each light show component relative to the first light show component to a grid. For example, method 1300 may construct a virtual space, and may divide the virtual space into a number of cells, as shown in FIG. 14D. In some examples, the virtual space is three-dimensional, while in other examples, the virtual space is two-dimensional. As an example, the light show system 1400 of FIG. 14D includes a virtual space comprising a two-dimensional grid 1418 of cells, onto which the set of mapping points of FIG. 14C are assigned or indexed.

In this way, method 1300 may determine relative locations of a plurality of light show components, and may index these locations (e.g., mapping points) to a grid. The relative locations of the plurality of light show components may be transmitted to a lighting controller, such as the lighting controller 108 of FIG. 1.

Continuing at 1310, method 1310 generates a light show based on the mapping points and the grid. For example, the lighting controller may modify a sequence of adjustments to the plurality of light show components according to the relative locations of the light show components. For example, the lighting controller may adjust a light show component based on its location relative to one or more cells in the virtual space. As an example, the lighting controller may determine to illuminate cell A-5 of FIG. 14D by adjusting globe light 1404a, causing it to illuminate. As another example, the lighting controller may determine to illuminate cell B-6 of FIG. 14D by adjusting a direction and intensity of spotlight 1406a such that a beam of light from spotlight 1406a is directed at cell B-6. Such adjustments may be coordinated by the lighting controller in order to achieve a variety of aesthetically pleasing effects while providing an automated light show, which may increase customer satisfaction. In particular, the lighting controller may synchronize adjustments to lights in order to highlight a certain feature of a music file, which may further increase customer satisfaction during an automated lighting show. Such dynamic sequences of lighting adjustments may enhance the harmony of an audio-visual synthesis provided by the light show. Method 1300 then returns.

It should be appreciated that the various systems and methods referred to herein for providing an automated light show may be combined. For example, mapping may be provided in a system including an Integrated Light Show Hub, which may generate a MFF and provide an automated light show based on a digital or analog music signal.

In one embodiment, a method comprises generating a music feature file based on selected audio, the music feature file comprising metadata for the selected audio including a plurality of time markers indicating audio events in the selected audio, and automatically controlling one or more lights according to the music feature file.

In a first example of the method, the method further comprises outputting the selected audio to one or more speakers, and synchronizing the automatic control of the one or more lights according to the music feature file with the output of the selected audio. In a second example of the method optionally including the first example, automatically controlling the lights according to the music feature file includes adjusting one or more of a color, state, beam movement, and intensity of the one or more lights based on one or more characteristics of the selected audio stored as the metadata of the music feature file. In a third example of the method optionally including one or more of the first and second examples, the metadata for the selected audio further includes a genre of the selected audio. In a fourth example of the method optionally including one or more of the first through third examples, the music feature file further comprises the selected audio. In a fifth example of the method optionally including one or more of the first through fourth examples, the music feature file further comprises a synchronized video file. In a sixth example of the method optionally including one or more of the first through fifth examples, the selected audio comprises an analog signal including the selected audio. In a seventh example of the method optionally including one or more of the first through sixth examples, the method further comprises receiving the selected audio from a remote streaming server, and generating the music feature file while receiving the selected audio. In an eighth example of the method optionally including one or more of the first through seventh examples, the selected audio comprises a music file stored in a memory of a controller. In a ninth example of the method optionally including one or more of the first through eighth examples, the method further comprises receiving a position for each of the one or more lights in a light show environment, mapping the position for each of the one or more lights to a grid corresponding to the light show environment, and further adjusting control of the one or more lights based on the mapped position for the one or more lights in the grid. In a tenth example of the method optionally including one or more of the first through ninth examples, the position for each of the one or more lights in a light show environment is determined based on a signal from a motion sensing device. In an eleventh example of the method optionally including one or more of the first through tenth examples, the motion sensing device is a mobile phone including BLUETOOTH. In a twelfth example of the method optionally including one or more of the first through eleventh examples, the motion sensing device is a mobile phone including a plurality of sensors.

In another embodiment, a light show system comprises a plurality of lights, and a controller communicatively coupled to the plurality of lights and configured with instructions stored in non-transitory memory that when executed by a processor of the controller cause the controller to control one or more lights of the plurality of lights based on a music feature file for a selected audio.

In a first example of the system, the system further comprises one or more speakers communicatively coupled to the controller, wherein the controller is further configured with instructions that when executed cause the controller to output the selected audio to the one or more speakers while

controlling the one or more lights of the plurality of lights based on the music feature file for the selected audio. In a second example of the system optionally including the first example, the controller is further configured with instructions that when executed cause the controller to: receive a second selected audio; retrieve a second music feature file for the second selected audio; and control one or more of the plurality of lights based on the second music feature file while outputting the second selected audio to the one or more speakers. In a third example of the system optionally including one or more of the first and second examples, the controller is further configured with instructions that when executed cause the controller to control one or more of the plurality of lights based on the music feature file and the second music feature file while transitioning between outputting the selected audio and the second selected audio to the one or more speakers. In a fourth example of the system optionally including one or more of the first through third examples, the plurality of lights are distributed throughout a light show environment, and the controller is further configured with instructions that when executed cause the controller to: receive a position of each light of the plurality of lights within the light show environment; map the position of each light to a virtual grid corresponding to the light show environment; and adjust control of the one or more lights based on the music feature file and the mapped position of each light in the virtual grid. In a fifth example of the system optionally including one or more of the first through fourth examples, the position of each light of the plurality of lights within the light show environment is determined based on a signal from a motion sensing device, the motion sensing device including a plurality of sensors.

The description of embodiments has been presented for purposes of illustration and description. Suitable modifications and variations to the embodiments may be performed in light of the above description or may be acquired from practicing the methods. For example, unless otherwise noted, one or more of the described methods may be performed by a suitable device and/or combination of devices, such as the vehicle systems and cloud computing systems described above with respect to FIGS. 1-14D. The methods may be performed by executing stored instructions with one or more logic devices (e.g., processors) in combination with one or more hardware elements, such as storage devices, memory, hardware network interfaces/antennas, switches, actuators, clock circuits, and so on. The described methods and associated actions may also be performed in various orders in addition to the order described in this application, in parallel, and/or simultaneously. The described systems are exemplary in nature, and may include additional elements and/or omit elements. The subject matter of the present disclosure includes all novel and non-obvious combinations and sub-combinations of the various systems and configurations, and other features, functions, and/or properties disclosed.

As used in this application, an element or step recited in the singular and proceeded with the word "a" or "an" should be understood as not excluding plural of said elements or steps, unless such exclusion is stated. Furthermore, references to "one embodiment" or "one example" of the present disclosure are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. The terms "first," "second," "third," and so on are used merely as labels, and are not intended to impose numerical requirements or a particular positional order on their objects. The following claims particularly

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point out subject matter from the above disclosure that is regarded as novel and non-obvious.

The invention claimed is:

1. A method executable by one or more processors according to instructions stored in memory, the method comprising:

obtaining metadata for a selected audio, the metadata identifying a plurality of song events in the selected audio and a plurality of trigger beats in the selected audio; and

automatically controlling one or more lights according to the metadata.

2. The method of claim 1, further comprising outputting the selected audio to one or more speakers, and synchronizing automatic control of the one or more lights according to the metadata with output of the selected audio.

3. The method of claim 1, wherein automatically controlling the one or more lights according to the metadata includes adjusting one or more of a color, a state, a beam movement, and an intensity of the one or more lights based on the plurality of song events and the plurality of trigger beats stored as the metadata.

4. The method of claim 1, wherein the metadata further includes one or more of a time signature, a number of beats per minute, a musical key, and a genre of the selected audio.

5. The method of claim 1, wherein the metadata is included in a music feature file that further comprises the selected audio.

6. The method of claim 1, wherein the metadata is included in a music feature file that further comprises a video file synchronized to the selected audio.

7. The method of claim 1, wherein the selected audio comprises an analog signal including the selected audio or a music file stored in the memory.

8. The method of claim 1, further comprising receiving the selected audio from a remote streaming server, and generating the metadata while receiving the selected audio.

9. The method of claim 1, further comprising receiving the selected audio and the metadata from a remote streaming server.

10. The method of claim 1, wherein the plurality of trigger beats indexes the plurality of song events of the selected audio to a timeline, and wherein the plurality of song events includes one or more of a break, an intro, a verse, a chorus, and a build-up.

11. The method of claim 1, wherein the metadata is included in a music feature file that comprises a plurality of packets, each packet of the plurality of packets including an entirety of the metadata.

12. The method of claim 1, further comprising receiving a position for each of the one or more lights in a light show environment, mapping the position for each of the one or more lights to a grid corresponding to the light show environment, and further adjusting control of the one or more lights based on the position mapped for the one or more lights in the grid.

13. The method of claim 12, wherein the position for each of the one or more lights in the light show environment is determined based on a signal from a motion sensing device.

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14. A light show system, comprising:

a plurality of lights; and

a controller communicatively coupled to the plurality of lights and configured with instructions stored in non-transitory memory that when executed by a processor of the controller cause the controller to:

control one or more lights of the plurality of lights based on metadata of a music feature file for a selected audio file, the metadata including a plurality of song events and a plurality of trigger beats in the selected audio file, wherein the music feature file further comprises a video file synchronized to the selected audio file.

15. The light show system of claim 14, wherein the video file is segmented based on one or more of the plurality of song events and the plurality of trigger beats, and wherein the music feature file includes the selected audio file.

16. The light show system of claim 14, wherein the plurality of lights is distributed throughout a light show environment, and wherein the controller is further configured with instructions that when executed cause the controller to:

receive a position of each light of the plurality of lights within the light show environment;

map the position of each light to a virtual grid corresponding to the light show environment; and

adjust control of the one or more lights based on the metadata of the music feature file and the mapped position of each light in the virtual grid.

17. A system, comprising:

a plurality of lights and a plurality of speakers arranged in a light show environment; and

a controller with computer-readable instructions stored on non-transitory memory thereof that when executed enable the controller to:

in response to a request for a light show for a selected audio file, obtain a music feature file for audio data of the selected audio file, wherein the music feature file comprises one or more of a plurality of song events, a plurality of trigger beats, a genre, a time signature, a number of beats per minute, and a musical key of the audio data;

signal to the plurality of lights to adjust one or more of a color, an intensity, a pulsation, and a brightness based on the music feature file; and

signal to the plurality of speakers to play audio based on the selected audio file.

18. The system of claim 17, wherein the music feature file comprises the plurality of song events and the plurality of trigger beats, and wherein the plurality of trigger beats index the plurality of song events to a timeline.

19. The system of claim 18, wherein the plurality of song events includes one or more of a break, an intro, a verse, a chorus, and a build-up.

20. The system of claim 17, wherein the one or more of the plurality of song events, the plurality of trigger beats, the genre, the time signature, the number of beats per minute, and the musical key are saved as metadata of the music feature file, and wherein the music feature file further includes the selected audio file.

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