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Serry et al.

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(54) **TEXTLESS MATERIAL SCENE MATCHING IN VIDEOS**

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(60) Provisional application No. 63/325,499, filed on Mar. 30, 2022.

(51) **Int. Cl.**

G06V 20/40	(2022.01)
G06V 20/62	(2022.01)
G11B 27/036	(2006.01)

(52) **U.S. Cl.**
CPC ***G06V 20/48*** (2022.01); ***G06V 20/46*** (2022.01); ***G06V 20/635*** (2022.01); ***G11B 27/036*** (2013.01)

(58) **Field of Classification Search**
CPC G06V 20/48; G06V 20/46; G06V 20/635; G11B 27/036
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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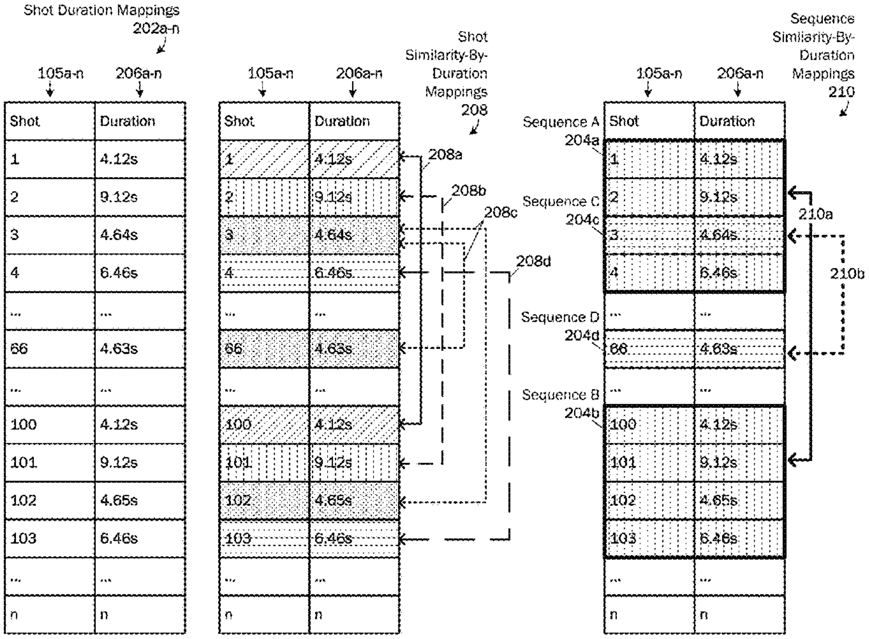
* cited by examiner

Primary Examiner — Girumsew Wendmagegn

(57) **ABSTRACT**

Systems, methods, and a computer-readable medium are provided for matching textless elements to texted elements in video content. A video processing system including a textless matching system may divide a video into shots, identify shots having similar durations, identify sequences of shots having similar durations, and compare image content in representative frames of the sequences to determine whether the sequences match. When the sequences are determined to match, the sequences may be paired, wherein the first sequence may include shots with overlaid text and the second sequence may include textless version of corresponding texted shots included in the first sequence. In some examples, the video processing system may further replace the determined corresponding texted shots.

20 Claims, 7 Drawing Sheets



Shot	Duration
1	4.12s
2	9.12s
3	4.64s
4	6.46s
...	...
66	4.63s
...	...
100	4.12s
101	9.12s
102	4.65s
103	6.46s
...	...
n	n

Shot	Duration
1	4.12s
2	9.12s
3	4.64s
4	6.46s
...	...
66	4.63s
...	...
100	4.12s
101	9.12s
102	4.65s
103	6.46s
...	...
n	n

Shot	Duration
1	4.12s
2	9.12s
3	4.64s
4	6.46s
...	...
66	4.63s
...	...
100	4.12s
101	9.12s
102	4.65s
103	6.46s
...	...
n	n

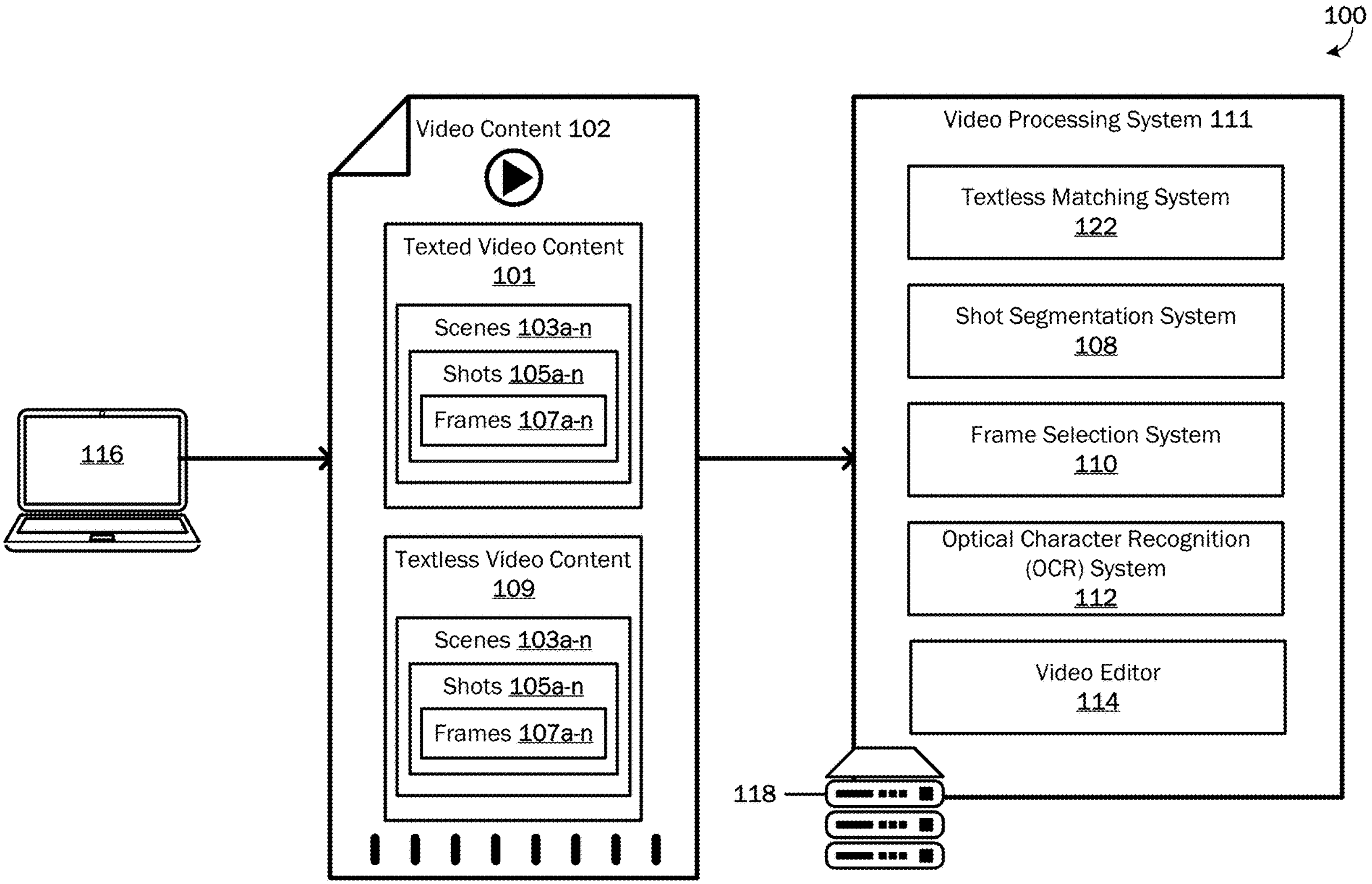
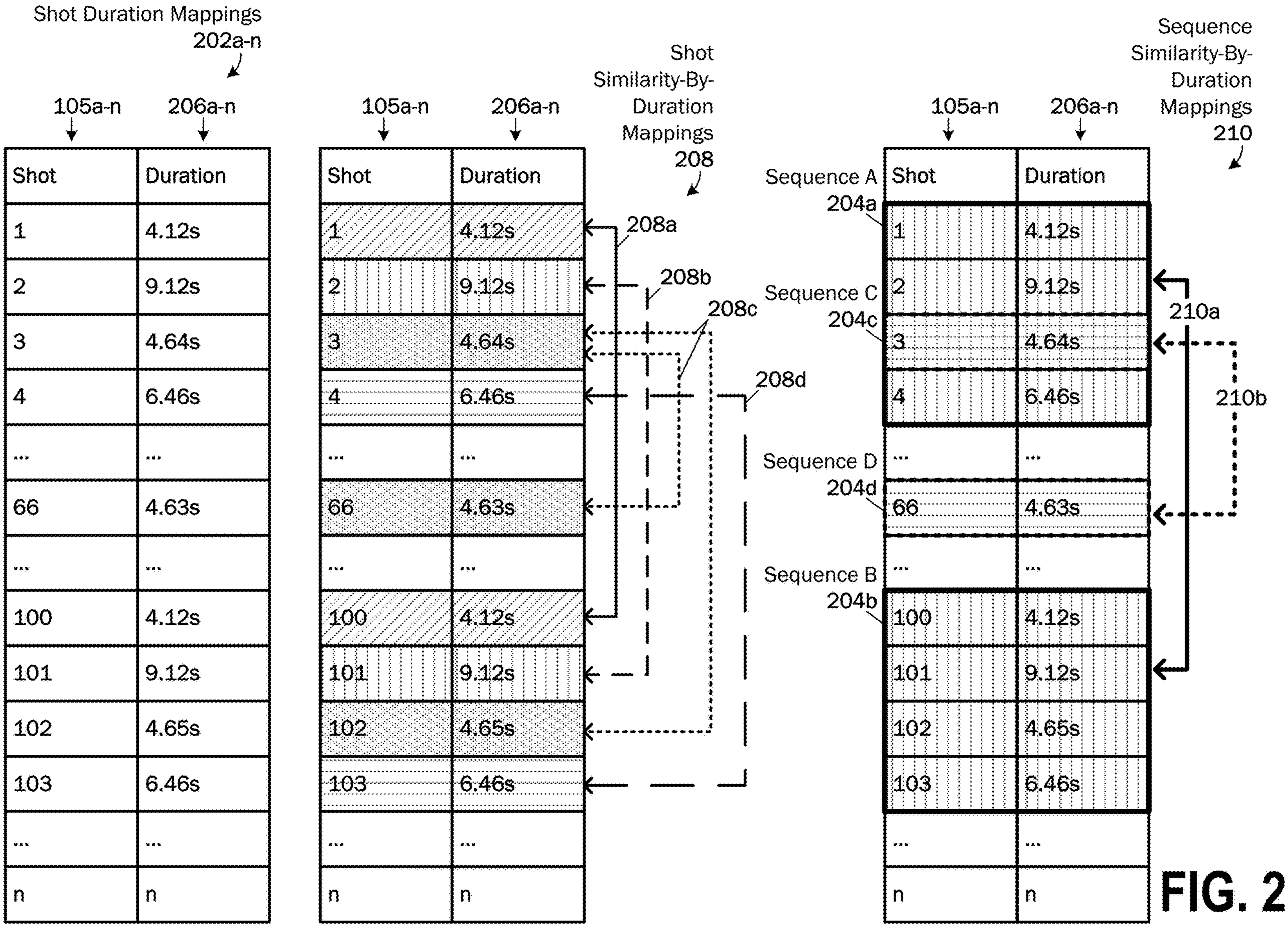

100
116
Video Content 102
Texted Video Content
101
Scenes 103a-n
Shots 105a-n
Frames 107a-n
Textless Video Content
109
Scenes 103a-n
Shots 105a-n
Frames 107a-n
Video Processing System 111
Textless Matching System
122
Shot Segmentation System
108
Frame Selection System
110
Optical Character Recognition
(OCR) System
112
Video Editor
114
118

FIG. 1



Shot Duration Mappings 202a-n

Shot	Duration
1	4.12s
2	9.12s
3	4.64s
4	6.46s
...	...
66	4.63s
...	...
100	4.12s
101	9.12s
102	4.65s
103	6.46s
...	...
n	n

Shot Similarity-By-Duration Mappings 208

Shot	Duration
1	4.12s
2	9.12s
3	4.64s
4	6.46s
...	...
66	4.63s
...	...
100	4.12s
101	9.12s
102	4.65s
103	6.46s
...	...
n	n

Sequence Similarity-By-Duration Mappings 210

Shot	Duration
1	4.12s
2	9.12s
3	4.64s
4	6.46s
...	...
66	4.63s
...	...
100	4.12s
101	9.12s
102	4.65s
103	6.46s
...	...
n	n

FIG. 2

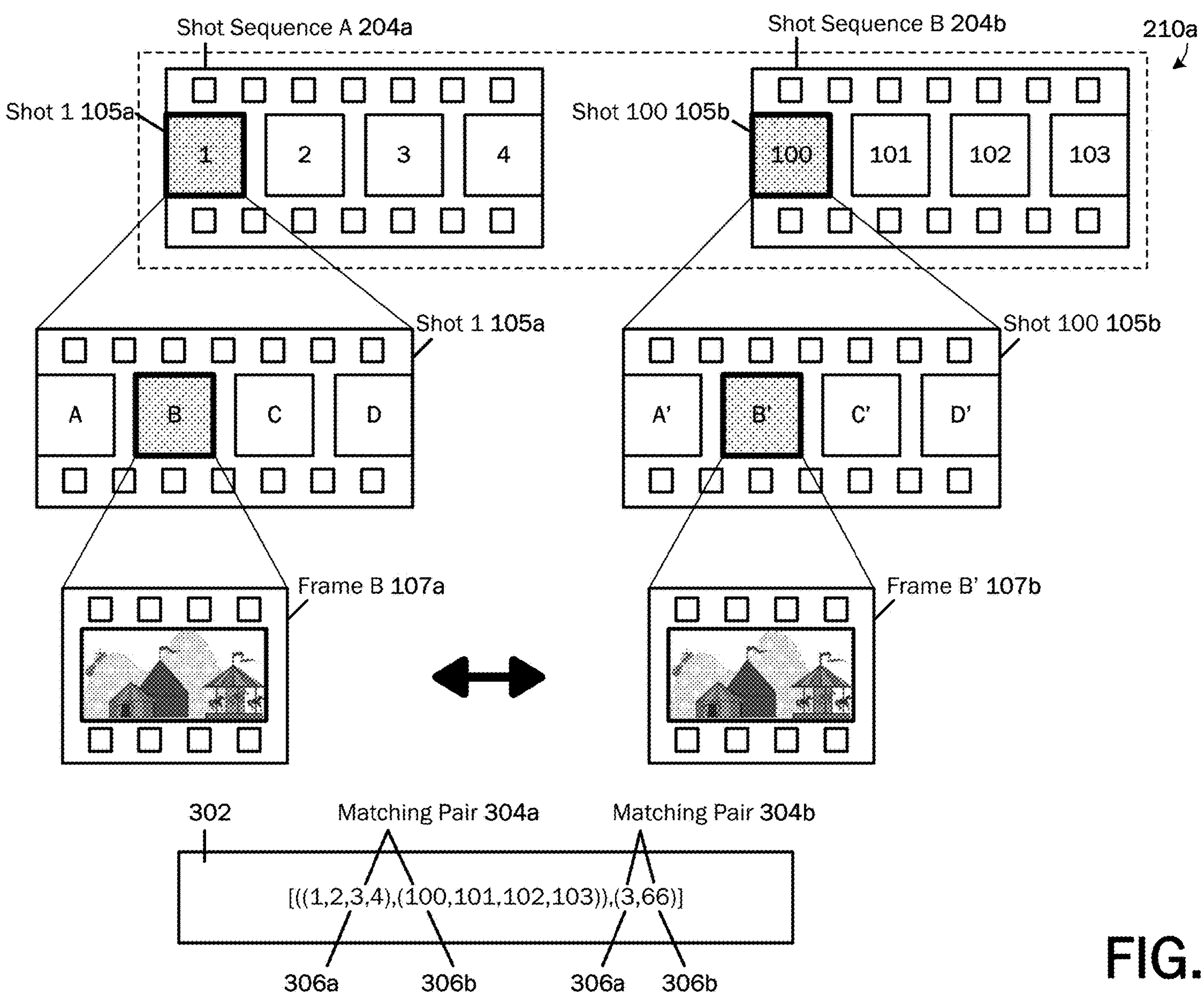

Shot Sequence A 204a
Shot Sequence B 204b
210a
Shot 1 105a
1
2
3
4
Shot 100 105b
100
101
102
103
Shot 1 105a
A
B
C
D
Shot 100 105b
A'
B'
C'
D'
Frame B 107a
Frame B' 107b
302
Matching Pair 304a
Matching Pair 304b
[((1,2,3,4),(100,101,102,103)),(3,66)]
306a
306b
306a
306b

FIG. 3

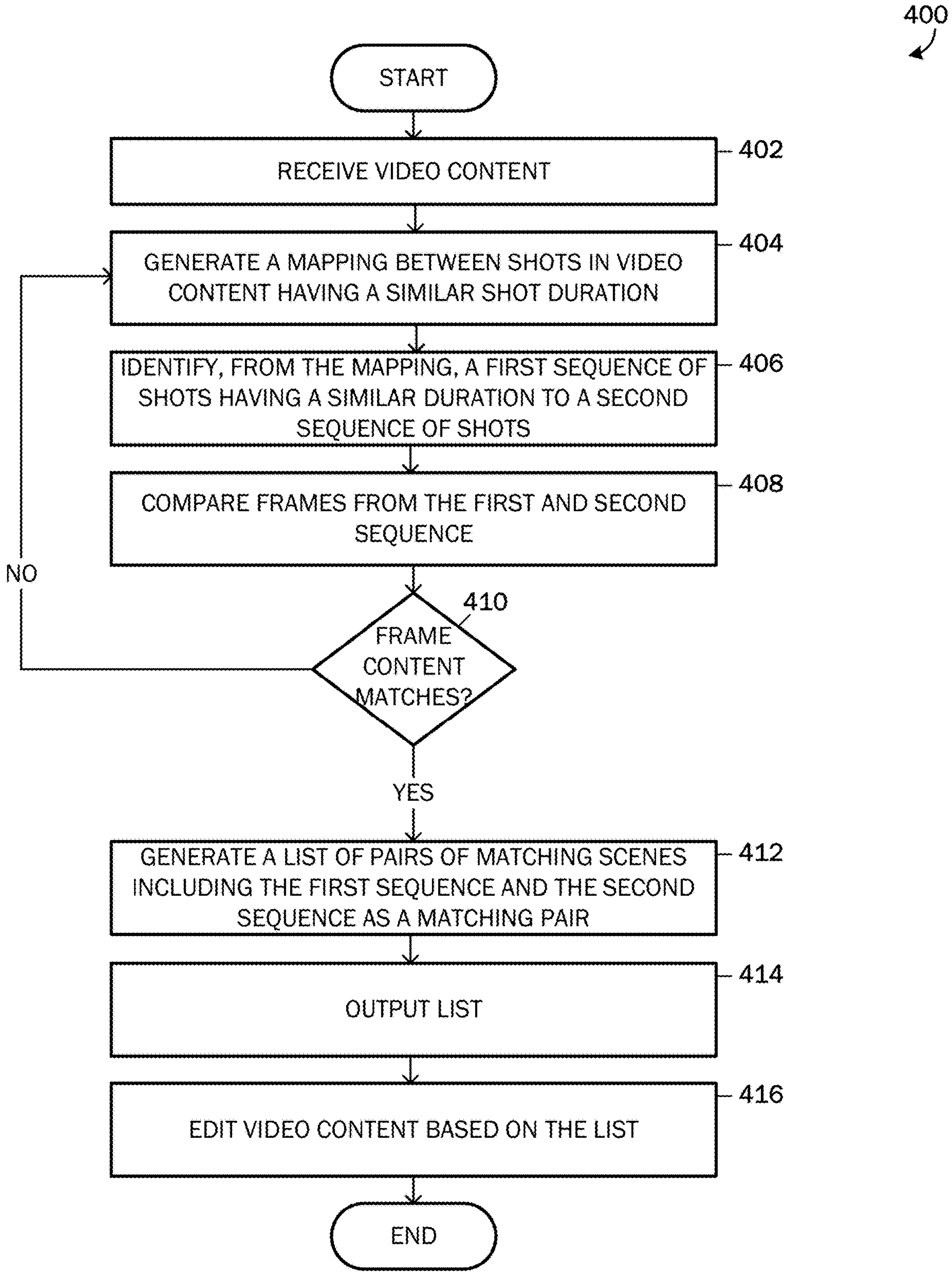

400
START
RECEIVE VIDEO CONTENT
402
GENERATE A MAPPING BETWEEN SHOTS IN VIDEO CONTENT HAVING A SIMILAR SHOT DURATION
404
IDENTIFY, FROM THE MAPPING, A FIRST SEQUENCE OF SHOTS HAVING A SIMILAR DURATION TO A SECOND SEQUENCE OF SHOTS
406
COMPARE FRAMES FROM THE FIRST AND SECOND SEQUENCE
408
NO
410
FRAME CONTENT MATCHES?
YES
GENERATE A LIST OF PAIRS OF MATCHING SCENES INCLUDING THE FIRST SEQUENCE AND THE SECOND SEQUENCE AS A MATCHING PAIR
412
OUTPUT LIST
414
EDIT VIDEO CONTENT BASED ON THE LIST
416
END

FIG. 4

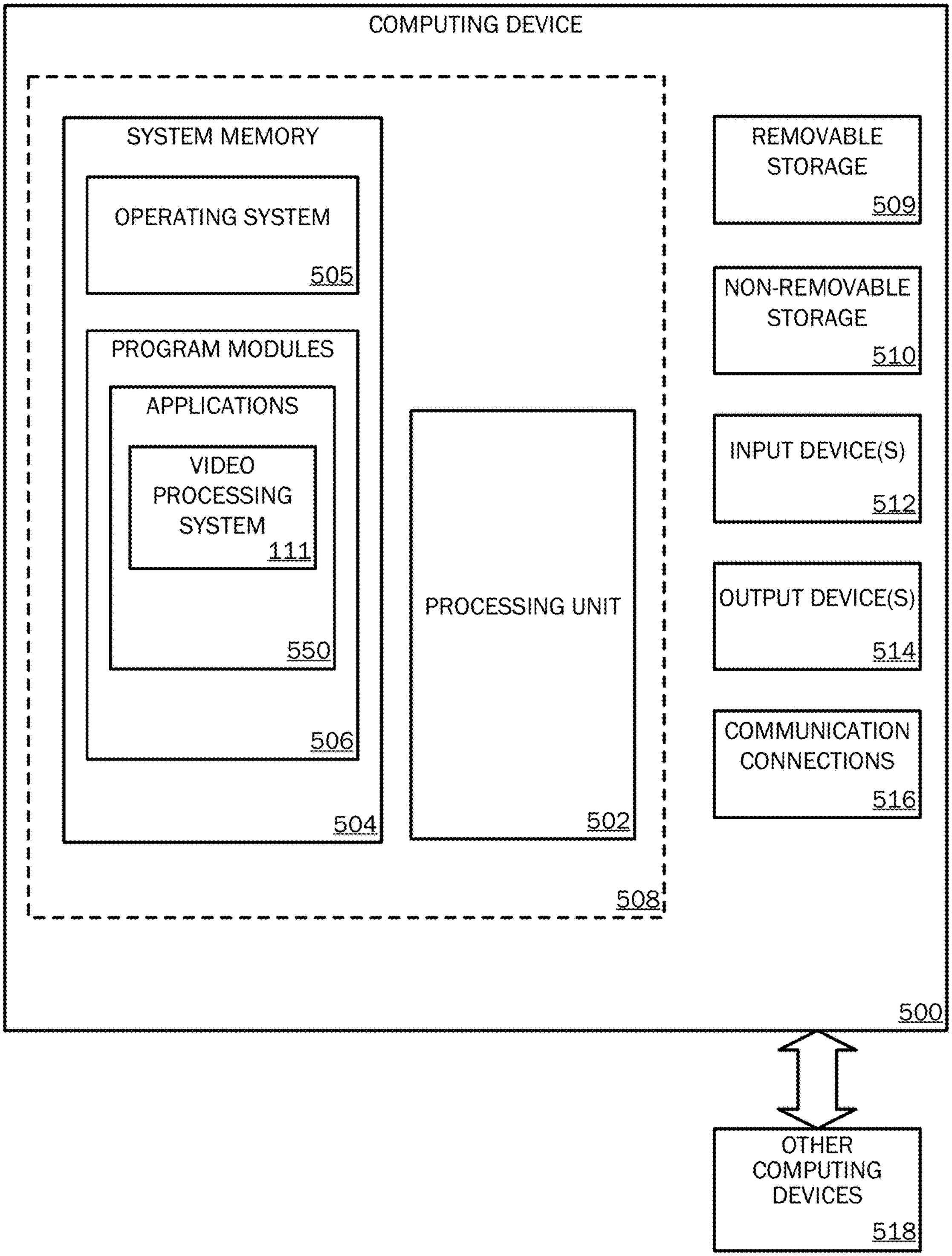

COMPUTING DEVICE
SYSTEM MEMORY
OPERATING SYSTEM
505
PROGRAM MODULES
APPLICATIONS
VIDEO PROCESSING SYSTEM
111
550
506
504
PROCESSING UNIT
502
508
REMOVABLE STORAGE
509
NON-REMOVABLE STORAGE
510
INPUT DEVICE(S)
512
OUTPUT DEVICE(S)
514
COMMUNICATION CONNECTIONS
516
500
OTHER COMPUTING DEVICES
518

FIG. 5

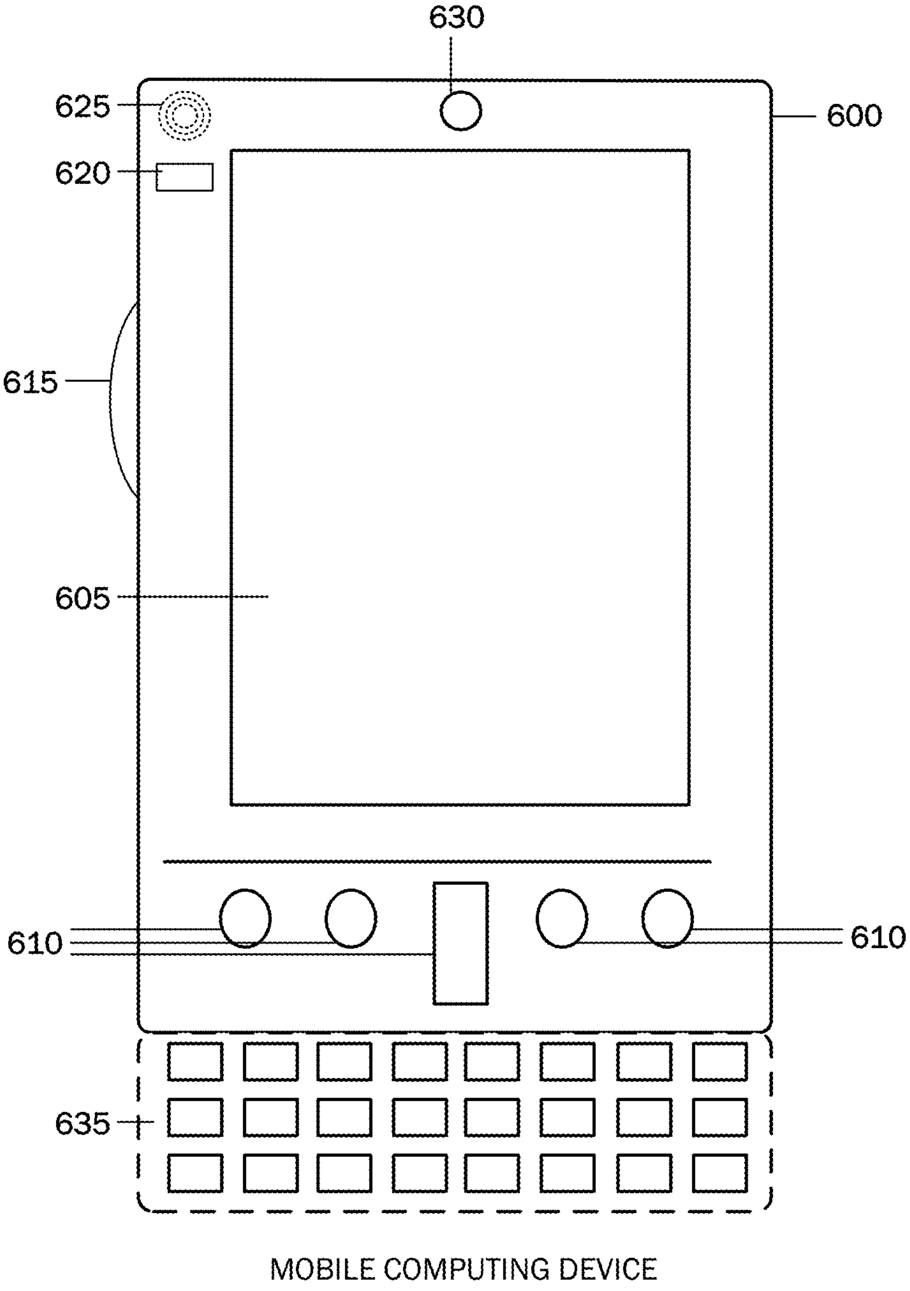


FIG. 6A

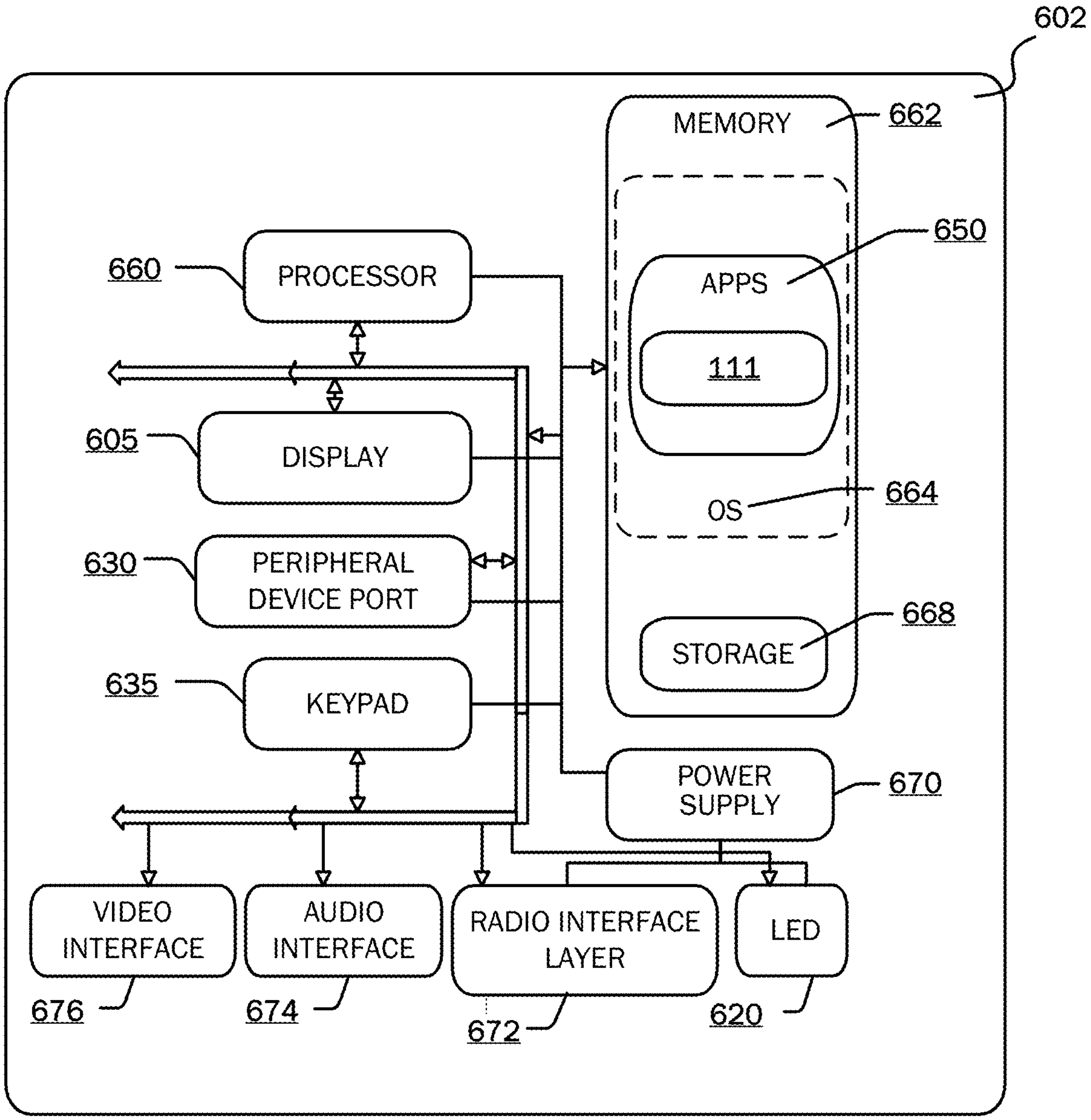

602
MEMORY
662
650
APPS
111
OS
664
STORAGE
668
660
PROCESSOR
605
DISPLAY
630
PERIPHERAL DEVICE PORT
635
KEYPAD
POWER SUPPLY
670
VIDEO INTERFACE
676
AUDIO INTERFACE
674
RADIO INTERFACE LAYER
672
LED
620

FIG. 6B

TEXTLESS MATERIAL SCENE MATCHING IN VIDEOS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 17/804,188 filed May 26, 2022, which claims the benefit of U.S. Provisional Patent Application No. 63/325,499, filed Mar. 30, 2022, and which applications are incorporated herein by reference their entireties entirety. To the extent appropriate a claim of priority is made to each of the above disclosed applications.

BACKGROUND

As part of preparing a video for distribution, it is common practice to include, at the end of the video, footage from the video from which text (e.g., opening and end titles, subtitles, location titles, forced narratives, lower thirds, and/or other writing superimposed over video shots) has been removed. This additional footage is referred to as textless material, and the shots or sequences of shots included in this additional footage are referred to as textless elements. The textless material is used to localize or re-text a video for foreign-speaking destinations, as well as in the design of user interface menus and/or in marketing and publicity materials. As an example, a distributor associated with a foreign region may insert shots of textless elements at the end of a video to replace corresponding shots of texted elements. Accordingly, text in a language of the foreign region may be added to (e.g., superimposed over) these text elements to produce the video in the foreign language for distribution in the foreign region and/or other regions.

It is with respect to these and other considerations that examples have been made. In addition, although relatively specific problems have been discussed, it should be understood that the examples should not be limited to solving the specific problems identified in the background.

SUMMARY

Examples of the present disclosure describe systems and methods for matching textless elements to texted elements in video content. A video processing system including a textless matching system may divide a video into shots, identify shots having similar durations, identify sequences of shots having similar durations, and compare image content in representative frames of the sequences to determine whether the sequences match. When the sequences are determined to match, the sequences may be paired, wherein the first sequence may include shots with overlaid text and the second sequence may include textless version of corresponding texted shots included in the first sequence.

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Additional aspects, features, and/or advantages of examples will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate various aspects of the present invention. In the drawings:

FIG. **1** depicts a system for providing matching textless elements to texted elements in a video content according to an example.

FIG. **2** depicts example mappings determined between shots included in a video content.

FIG. **3** depicts an example comparison between frames in matching sequences of shots having a similar duration.

FIG. **4** depicts an example method for matching textless elements to texted elements in a video content.

FIG. **5** is a block diagram illustrating example physical components of a computing device with which aspects of the invention may be practiced.

FIGS. **6**A and **6**B are simplified block diagrams of a mobile computing device with which aspects of the present invention may be practiced.

DETAILED DESCRIPTION

As briefly discussed above, video content may include textless material including textless shots (referred to herein as textless elements) on which text has not been superimposed over shots in the video content or from which text superimposed over shots in the video content has been removed. Previous methods of matching textless material to corresponding texted material are performed manually by a video content distributor. As can be appreciated, these manual methods are not only be time-consuming and result in inefficient utilization of employees and computing resources, but are also prone to human error. Accordingly, a textless material matching system is provided herein that operates to automatically match textless material to texted material in video content. In some embodiments, the textless material matching system is in communication with or integrated with a video editing system that automatically replaces texted material with corresponding textless material. As can be appreciated, automated matching of texted and textless video material not only increases the speed of distribution of translated video content for multiple languages, but may also increase the accuracy of matched texted and textless material. These and other examples are described below with reference to FIGS. **1**-**6**B.

With reference now to FIG. **1**, an example operating environment **100** is depicted in which a video processing system **111** comprising a textless matching system **122** is implemented for providing automated matching of texted and textless video material in video content **102**. In an example, the video processing system **111** includes one or more server computer devices **118** supporting video processing. The server computer devices **118** includes web servers, application servers, network appliances, dedicated computer hardware devices, virtual server devices, personal computers, a system-on-a-chip (SOC), or any combination of these and/or other computing devices known in the art. As will be described herein, the video processing system **111** operates to execute a number of computer readable instructions, data structures, or program modules to provide automated matching of texted and textless video material for matching textless elements to texted elements in video content **102**.

According to examples, the video processing system **111** receives video content **102** from a video content provider **116**. The video content **102** includes video data in a video coding format. The video content **102** may further include audio data in an audio coding format, synchronization information, subtitles, and metadata. As is known in the art, video content **102** is comprised of a series of images captured by a camera, where each image is a frame **107***a*-*n* (collectively, **107**). A shot **105***a-n* (collectively, **105**) includes one or more frames **107** captured during an uninterrupted period of time from when the camera starts recording to when it stops recording (e.g., a single take). For instance, a shot **105** includes a sequence of consecutive frames **107** with no interruption. Typically, the video content **102** includes a plurality of scenes **103***a-n* (collectively, **103**), which include a shot **105** or a plurality of shots **105**. In an example, the shot or shots **105** of a scene **103** together comprise a single, unified dramatic event, action, unit, or element of video content narration. In another example, a scene is a segment of storytelling within video content.

In an example, some of the scenes **103** included in the video content **102** are included in a texted version of video content. The texted version of video content is herein referred to as texted video content **101** (e.g., the production version). The texted video content **101** includes a portion of shots **105** that include text superimposed over the video content images. These shots **105** including superimposed text are herein referred to as texted elements. In examples, the text includes opening and end titles, subtitles, location titles, forced narratives, lower thirds, and/or other writing superimposed over the video content. Further, as described above, the video content **102** may additionally include textless video content **109** (e.g., at the end of the file). In examples, the textless video content **109** includes textless versions of the texted elements. That is, the video content **102** includes a plurality of scenes **103**, where some scenes **103** may include texted elements and other scenes **103** include textless elements.

According to an example implementation and as depicted in FIG. **1**, the video processing system **111** includes a textless matching system **122** and includes, or is in communication with, a shot segmentation system **108**, a frame selection system **110**, and an optical character recognition (OCR) system **112**. In an example, various components of the video processing system **111** communicate via various application programming interfaces (APIs). In some examples, the video processing system **111** further includes a video editor **114**. In other examples, the video editor **114** is part of a separate system. Each of the textless matching system **122**, shot segmentation system **108**, frame selection system **110**, OCR system **112**, and video editor **114** are illustrative of a software application, system, or module that operates on a server computer device **118** or across a plurality of server computer devices **118**.

According to an aspect, after receiving the video content **102**, the shot segmentation system **108** segments the video content **102** into a plurality of shots **105**. For example, the shot segmentation system **108** is configured to analyze the frames **107** of the video content **102** and determine sets of frames **107** that include images taken contiguously by a single camera and represented in a continuous action in time and space. The shot segmentation system **108** may use any standard technique known in the art. An example technique includes evaluating consecutive frames **107** of the video content **102** and determining a similarity score representing a similarity or dissimilarity between the two frames **107**. The similarity scores between the frames **107** are evaluated, and a hard and or soft cut is detected between two frames **107** when the score meets or exceeds an absolute or relative threshold value representative of detected shot transition (e.g., abrupt or gradual transitions). Accordingly, the shot segmentation system **108** determines which sequences of one or more frames **107** are grouped as a shot **105**.

Additionally, the shot segmentation system **108** further generates a first set of mappings between shots **105** and shot durations **206**. The mappings included in the first set are herein referred to as shot duration mappings **202***a-n* (collectively, **202**). Example shot duration mappings **202** are depicted in FIG. **2**, where the shot duration mappings **202** are presented as an index and each determined shot **105** is identified by an index value (e.g., 1-n) and associated with a time unit (e.g., seconds(s)) corresponding to a duration **206** of the shot **105**.

In the illustrated example, the shot duration mappings **202** indicate that a 1st shot is 4.12 seconds (s) in duration, a 2nd shot is 9.12 s, a 3rd shot is 4.64 s, a 66th shot is 6.63 s, a 100th shot is 4.12 s, a 101st shot is 9.12 s, a 102nd shot is 4.65 s, and a 103rd shot is 6.46 s.

According to an example, the textless matching system **122** operates to access the shot duration mappings **202** and generate a second set of mappings between shots **105** with similar durations **206**. The mappings included in the second set are herein referred to as shot similarity by duration mappings **208**. In some implementations, a determination of duration similarity is based on absolute threshold time differences. In other implementations, the determination of duration similarity is based on relative threshold time differences. Example shot similarity-by-duration mappings **208** are shown in FIG. **2**, where a first shot similarity-by-duration mapping **208***a* is determined between the 1st shot and the 100th shot; a second shot similarity-by-duration mapping **208***b* is determined between the 2nd shot and the 101st shot; a third set of shot similarity-by-duration mappings **208***c* is determined between the 3rd shot and the 66th shot and between the 3rd shot and the 102nd shot; and a fourth shots similarity-by-duration mapping **208***d* is determined between the 4th shot and the 103rd shot. For instance, the third set of shot similarity-by-duration mappings **208***c* may be determined based on a relative threshold time difference, which, in the illustrated example, is less than 0.02 s. As shown, the difference in durations between the 3rd shot and the 66th shot is 0.01 s, which is within the threshold time difference of less than 0.02 s. Additionally, the difference in durations between the 3rd shot and the 102nd shot is 0.1 s, which is also within the threshold time difference of less than 0.02 s. Thus, the 3rd shot is determined to be similar to the 66th and 102nd shots. However, the 0.2 s difference in durations between the 66th shot and the 102nd shot is above the threshold time difference, which causes the textless matching system **122** to determine that the 66th shot is dissimilar from the 102nd shot.

In some examples, the textless matching system **122** further evaluates the shot similarity-by-duration mappings **208** to identify pairs of sequences **204***a-d* (collectively, **204**) that include a matching number of shots **105** and matching shot durations **206** and generate a third set of mappings between each pair of sequences **204**. The mappings generated between pairs of sequences **204** having matching numbers of shots **105** and shot durations **206** are herein referred to as shot sequence similarity-by-duration mappings **210**. According to one example, a sequence **204** of shots **105** is a scene **103**. In some implementations, determinations of shot number and duration matching are based on an absolute threshold number and/or time differences. In other implementations, determinations of shot number and duration matching are based on a relative threshold number and/or time differences. As an example, a first sequence (e.g., sequence A **204***a*) is identified to include shots **1-4**, a second sequence (e.g., sequence B **204***b*) is identified to include shots **100-103**, a third sequence (e.g., sequence C **204***c*) is identified to include shot **3**, and a fourth sequence (e.g., sequence D **204***d*) is identified to include shot **4**.

Example shot sequence similarity-by-duration mappings **210** between pairs of sequences **204** are shown in FIG. **2**. For instance, each pair of sequences **204** are comprised of an earlier occurring sequence (referred to herein as an early sequence) and a later occurring sequence (referred to herein as a late sequence). As an example, a first shot sequence similarity-by-duration mapping **210***a* is identified between sequence A **204***a* and sequence B **204***b* (and represented by vertical cross-hatching). Additionally, other mapping information is determined for each mapping **210**, such as a number of shots **205** in each of the sequences **204** in the pair (e.g., 4 shots), the index value of the first shot of the early sequence (e.g., 1), the index value of first shot of the late sequence (e.g., 100), a total duration of each sequence in the pair (e.g., 24.34 s), and a confidence score. A second example shot sequence similarity-by-duration mapping **210***b* is identified between sequence C **204***c* and sequence D **204***d* (and represented by horizontal cross-hatching), where each sequence **204** has one shot having a duration of 4.64 s, the 3rd shot is the first shot of the early sequence, and the 66th shot is the first shot of the late sequence.

In some examples, the textless matching system **122** further operates to filter the identified shot sequence similarity-by-duration mappings **210** to remove mappings that do not meet one or more thresholds from further analysis. In one example implementation, the shot sequence similarity-by-duration mappings **210** are filtered based on a minimal number (threshold) of consecutive shots **105** in a sequence **204**. In another example implementation, the shot sequence similarity-by-duration mappings **210** are filtered based on a minimal sequence duration threshold. For example, shorter sequences **204** that are determined to not meet the threshold are omitted from further evaluation, where sequences **204** that meet or exceed the threshold are passed through the filter for further evaluation. In another example implementation, the shot sequence similarity-by-duration mappings **210** are filtered based on another attribute.

In some examples, and with reference to FIG. **3**, the frame selection system **110** operates to select a representative corresponding frame (e.g., **107***a* and **107***b*) from each identified sequence (e.g., **204***a* and **204***b*) in each shot sequence similarity-by-duration mapping (e.g., **210***a*) for comparison. In one example implementation, the representative frames **107** is selected periodically (e.g., according to a selected or random time in the sequence). In another example implementation, the representative frames **107** are selected based on one or more descriptive attributes of the frames, such as frames having high contrast and/or stability, among other attributes.

The frame selection system **110** further operates to compare the selected representative frames **107** using an image comparison metric, such as Mean Squared Error (MSE). Other example image comparison metrics that can be used in addition to or as an alternative to MSE include normalized correlation, pattern intensity, and mutual information. For example, the frame selection system **110** may be configured to use any standard technique known in the art to analyze the selected representative frames **107** to determine whether the image content in the frames **107** (and, thus, the associated shots **105**) match. In some examples, prior to the comparison, the OCR system **112** operates to detect and mark areas to ignore where text is present in a frame **107**. When representative frames **107** in a mapping **210** are determined to match, the frames are included in a first output, which may include a list **302** of matching pairs **304***a,b* (generally, **304**) of detected matched scenes **103** (e.g., sequences **204** of shots **105**). In some examples, matched scenes **103** included in the list **302** differ only in the presence or absence of overlaid text. For instance, shots **100-103** of shot sequence B **204***b* are determined to be textless versions of texted versions of shots **1-4** of shot sequence A **204***a*. Additionally, shot **66** of shot sequence D **204***d* is determined to be a textless version of a texted version of shot **3** of shot sequence C **204***c*. In examples, the first output is provided to the video editor **114**, which operates to replace the early sequence **306***a* of the matching pair **304** with the late sequence **306***b* of the pair, thereby replacing the texted scene **103** with the textless scene **103**. In some examples, if text was detected in the early sequence **306***a* (that was not removed), the first output may include a signal to the video editor **114** to insert translated text in this part of the video content **102**. In examples, a second output is provided by the video editor **114**, which may include an edited video content **102** including texted scenes **103** replaced with textless scenes **103**.

FIG. **4** depicts an example method **400** for matching textless elements to texted elements in video content **102**. The operations of method **400** may be performed by one or more computing devices, such as one or more computing devices included in the video processing system **111**. For example, the method **400** is performed by the one or more of the textless matching system **122**, the shot segmentation system **108**, the frame selection system **110**, the OCR system **112**, and the video editor **114** depicted in FIG. **1**.

At operation **402**, video content **102** is received. For example, the video processing system **111** receives the video content **102** from a video content provider **116**. The video content **102** includes a texted version of video content **101** and textless video content **109** including one or more scenes **103** from which text included in a corresponding scene of the texted version of video content **101** has be removed.

At operation **404**, a first set of mappings (e.g., shots duration mappings **202**) are generated between the shots **105** included in the video content **102** and the durations of the shots **105** (e.g., shot durations **206**). For example, the video content **102** is segmented into a plurality of shots **105**, each including a sequence of consecutive frames **107** without interruption. In segmenting the video content **102**, the shot segmentation system **108** analyzes the frames **107**, detects shot transitions (e.g., abrupt or gradual transitions), and determines which sequences of one or more frames **107** are grouped as a shot **105**. Further, an index including shot duration mappings **202** between an index value associated with each determined shot **105** and the shot's duration **206** is generated.

At operation **406**, sequences **204** of shots **105** included in the index having similar durations are identified. For example, shot similarity-by-duration mappings **208** between a shot **105** and an array of one or more shots **105** with similar durations **206** are generated. In some examples, the shot similarity-by-duration mappings **208** are evaluated to identify shot sequence similarity-by-duration mappings **210** between pairs of sequences **204** that include a matching number of shots **105** and matching shot durations **206**. In an example, additional mapping information is determined for each mapping **210** (e.g., a number of shots **205** in the sequences **204**, the index value of the first shot of the early sequence of the pair, the index value of first shot of the late sequence of the pair, a total duration of each sequence in the pair, a confidence score). In some examples, the identified shot sequence similarity-by-duration mappings **210** is filtered. In one example, shorter sequences **204** that are determined to not meet a sequence length (or other) threshold are omitted from further evaluation.

At operation **408**, corresponding frames **107** in a pair of sequences **204** are selected and compared. For example, a representative frame **107** from each identified sequence **204** in each shot sequence similarity-by-duration mapping (e.g., shot sequence similarity-by-duration mapping **210**) is selected periodically or based on one or more descriptive attributes of the frames **107**. The selected representative frames **107** are compared using an image comparison metric, such as Mean Squared Error (MSE) for determining whether the image content in the frames **107** (and, thus, the associated shots **105**) match. In some examples, prior to the comparison, text that is present in a frame **107** is detected and marked to ignore in the comparison.

At decision operation **410**, a determination may be made as to whether image content included in the representative frames **107** match. For example, when a determination is made that the representative frames **107** in a shot sequence similarity-by-duration mapping match, at operation **412**, a list **302** of matching pairs **304** of detected matched scenes **103** (e.g., sequences **204** of shots **105**) is generated. Each matched scene **103** includes an early sequence **306***a* of shots **105** including one or more texted frames **107** and a late sequence **306***b* of shots **105** including one or more textless frames **107**.

At optional operation **414**, the list **302** is output to a video editor **114**, where the textless scenes **103** replaces the determined corresponding texted scenes **103**. In some examples, the video editor **114** is included in the video processing system **111**, and the output of the system includes an edited video content **102**. At optional operation **416**, texted scenes **103** may be replaced with the textless scene **103**. In some examples, further processing of the edited video content **102** is performed, such as adding text in a language of a foreign region to the replaced texted scenes **103** to produce the video content **102** in the foreign language.

FIGS. **5**, **6**A, and **6**B and the associated descriptions provide a discussion of a variety of operating environments in which examples of the invention may be practiced. However, the devices and systems illustrated and discussed with respect to FIGS. **5**, **6**A, and **6**B are for purposes of example and illustration and are not limiting of a vast number of computing device configurations that may be utilized for practicing aspects of the invention, described herein.

FIG. **5** is a block diagram illustrating physical components (i.e., hardware) of a computing device **500** with which examples of the present disclosure may be practiced. The computing device components described below may be suitable for the video processing system **111** described above. In a basic configuration, the computing device **500** includes at least one processing unit **502** and a system memory **504**. Depending on the configuration and type of computing device **500**, the system memory **504** may comprise volatile storage (e.g., random access memory), non-volatile storage (e.g., read-only memory), flash memory, or any combination of such memories. The system memory **504** may include an operating system **505** and one or more program modules **506** suitable for running software applications **550**, such as one or more components of the video processing system **111**.

The operating system **505** may be suitable for controlling the operation of the computing device **500**. Furthermore, aspects of the invention may be practiced in conjunction with a graphics library, other operating systems, or any other application program and is not limited to any particular application or system. This basic configuration is illustrated in FIG. **5** by those components within a dashed line **508**. The computing device **500** may have additional features or functionality. For example, the computing device **500** may also include additional data storage devices (removable and/or non-removable) such as, for example, magnetic disks, optical disks, or tape. Such additional storage is illustrated in FIG. **5** by a removable storage device **509** and a non-removable storage device **510**.

As stated above, a number of program modules and data files may be stored in the system memory **504**. While executing on the processing unit **502**, the program modules **506** may perform processes including one or more of the stages of the method **400** illustrated in FIG. **4**. Other program modules that may be used in accordance with examples of the present invention and may include applications such as electronic mail and contacts applications, word processing applications, spreadsheet applications, database applications, slide presentation applications, drawing or computer-aided application programs, etc.

Furthermore, examples of the invention may be practiced in an electrical circuit comprising discrete electronic elements, packaged or integrated electronic chips containing logic gates, a circuit utilizing a microprocessor, or on a single chip containing electronic elements or microprocessors. For example, examples of the invention may be practiced via a system-on-a-chip (SOC) where each or many of the components illustrated in FIG. **5** may be integrated onto a single integrated circuit. Such an SOC device may include one or more processing units, graphics units, communications units, system virtualization units and various application functionality all of which are integrated (or "burned") onto the chip substrate as a single integrated circuit. When operating via an SOC, the functionality, described herein, with respect to matching textless elements to texted elements in video content **102**, may be operated via application-specific logic integrated with other components of the computing device **500** on the single integrated circuit (chip). Examples of the present disclosure may also be practiced using other technologies capable of performing logical operations such as, for example, AND, OR, and NOT, including mechanical, optical, fluidic, and quantum technologies.

The computing device **500** may also have one or more input device(s) **512** such as a keyboard, a mouse, a pen, a sound input device, a touch input device, a camera, etc. The output device(s) **514** such as a display, speakers, a printer, etc. may also be included. The aforementioned devices are examples and others may be used. The computing device **500** may include one or more communication connections **516** allowing communications with other computing devices **518**. Examples of suitable communication connections **516** include RF transmitter, receiver, and/or transceiver circuitry; universal serial bus (USB), parallel, and/or serial ports.

The term computer readable media as used herein may include computer storage media. Computer storage media may include volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information, such as computer readable instructions, data structures, or program modules. The system memory **504**, the removable storage device **509**, and the non-removable storage device **510** are all computer storage media examples (i.e., memory storage.) Computer storage media may include random access memory (RAM), read-only memory (ROM), electrically erasable programmable ROM (EEPROM), flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other article of manufacture which can be used to store information and which can be accessed by the computing device **500**. Any such computer storage media may be part of the computing device **500**. Computer storage media does not include a carrier wave or other propagated data signal.

Communication media may be embodied by computer readable instructions, data structures, program modules, or other data in a modulated data signal, such as a carrier wave or other transport mechanism, and includes any information delivery media. The term "modulated data signal" may describe a signal that has one or more characteristics set or changed in such a manner as to encode information in the signal. By way of example, communication media may include wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared, and other wireless media.

FIGS. **6**A and **6**B illustrate a mobile computing device **600**, for example, a mobile telephone, a smart phone, a tablet personal computer, a laptop computer, and the like, with which aspects of the invention may be practiced. With reference to FIG. **6**A, an example of a mobile computing device **600** for implementing at least some aspects of the present technology is illustrated. In a basic configuration, the mobile computing device **600** is a handheld computer having both input elements and output elements. The mobile computing device **600** typically includes a display **605** and one or more input buttons **610** that allow the user to enter information into the mobile computing device **600**. The display **605** of the mobile computing device **600** may also function as an input device (e.g., a touch screen display). If included, an optional side input element **615** allows further user input. The side input element **615** may be a rotary switch, a button, or any other type of manual input element. In alternative examples, mobile computing device **600** may incorporate more or less input elements. For example, the display **605** may not be a touch screen in some examples. In alternative examples, the mobile computing device **600** is a portable phone system, such as a cellular phone. The mobile computing device **600** may also include an optional keypad **635**. Optional keypad **635** may be a physical keypad or a "soft" keypad generated on the touch screen display. In various aspects, the output elements include the display **605** for showing a graphical user interface (GUI), a visual indicator **620** (e.g., a light emitting diode), and/or an audio transducer **625** (e.g., a speaker). In some examples, the mobile computing device **600** incorporates a vibration transducer for providing the user with tactile feedback. In yet another example, the mobile computing device **600** incorporates input and/or output ports, such as an audio input (e.g., a microphone jack), an audio output (e.g., a headphone jack), and a video output (e.g., a HDMI port) for sending signals to or receiving signals from an external device.

FIG. **6**B is a block diagram illustrating the architecture of one example of a mobile computing device. That is, the mobile computing device **600** can incorporate a system (i.e., an architecture) **602** to implement some examples. In one example, the system **602** is implemented as a "smart phone" capable of running one or more applications (e.g., videoconference or virtual meeting application, browser, e-mail, calendaring, contact managers, messaging clients, games, and media clients/players). In some examples, the system **602** is integrated as a computing device, such as an integrated personal digital assistant (PDA) and wireless phone.

One or more application programs **650** (e.g., one or more of the components of the video processing system **111**) may be loaded into the memory **662** and run on or in association with the operating system **664**, such as the textless matching system **122**, the shot segmentation system **108**, the frame selection system **110**, the OCR system **112** and/or the video editor **114**. Other examples of the application programs **650** include videoconference or virtual meeting programs, phone dialer programs, e-mail programs, personal information management (PIM) programs, word processing programs, spreadsheet programs, Internet browser programs, messaging programs, and so forth. The system **602** also includes a non-volatile storage area **668** within the memory **662**. The non-volatile storage area **668** may be used to store persistent information that should not be lost if the system **602** is powered down. The application programs **650** may use and store information in the non-volatile storage area **668**, such as e-mail or other messages used by an e-mail application, and the like. A synchronization application (not shown) also resides on the system **602** and is programmed to interact with a corresponding synchronization application resident on a host computer to keep the information stored in the non-volatile storage area **668** synchronized with corresponding information stored at a remote device or server. As should be appreciated, other applications may be loaded into the memory **662** and run on the mobile computing device **600**.

The system **602** has a power supply **670**, which may be implemented as one or more batteries. The power supply **670** might further include an external power source, such as an AC adapter or a powered docking cradle that supplements or recharges the batteries.

The system **602** may also include a radio **672** that performs the function of transmitting and receiving RF communications. The radio **672** facilitates wireless connectivity between the system **602** and the "outside world," via a communications carrier or service provider. Transmissions to and from the radio **672** are conducted under control of the operating system **664**. In other words, communications received by the radio **672** may be disseminated to the application programs **650** via the operating system **664**, and vice versa.

The visual indicator **620** (e.g., light emitting diode (LED)) may be used to provide visual notifications and/or an audio interface **674** may be used for producing audible notifications via the audio transducer **625**. In the illustrated example, the visual indicator **620** is a light emitting diode (LED) and the audio transducer **625** is a speaker. These devices may be directly coupled to the power supply **670** so that when activated, they remain on for a duration dictated by the notification mechanism even though the processor **660** and other components might shut down for conserving battery power. The LED may be programmed to remain on indefinitely until the user takes action to indicate the powered-on status of the device. The audio interface **674** is used to provide audible signals to and receive audible signals from the user. For example, in addition to being coupled to the audio transducer **625**, the audio interface **674** may also be coupled to a microphone to receive audible input, such as to facilitate a telephone conversation. The system **602** may further include a video interface **676** that enables an operation of a peripheral device port **630** (e.g., an on-board camera) to record still images, video stream, and the like.

A mobile computing device **600** implementing the system **602** may have additional features or functionality. For example, the mobile computing device **600** may also include additional data storage devices (removable and/or non-removable) such as, magnetic disks, optical disks, or tape. Such additional storage is illustrated in FIG. **6**B by the non-volatile storage area **668**.

Data/information generated or captured by the mobile computing device **600** and stored via the system **602** may be stored locally on the mobile computing device **600**, as described above, or the data may be stored on any number of storage media that may be accessed by the device via the radio **672** or via a wired connection between the mobile computing device **600** and a separate computing device associated with the mobile computing device **600**, for example, a server computer in a distributed computing network, such as the Internet. As should be appreciated such data/information may be accessed via the mobile computing device **600** via the radio **672** or via a distributed computing network. Similarly, such data/information may be readily transferred between computing devices for storage and use according to well-known data/information transfer and storage means, including electronic mail and collaborative data/information sharing systems.

As will be understood from the foregoing disclosure, many technical advantages and improvements over conventional textless content matching technologies result from the present technology. For instance, the present technology provides an automated process for matching textless elements to texted elements in video content **102** based on shot-based and sequence-based mappings between different shots in the video content. Automation of this previously manual process provides an efficient and reliable method for interacting with textless content and increases the speed at which media content can be translated to different languages and distributed.

As will also be understood from the foregoing disclosure, in an aspect, the present technology relates to a system for automatically matching textless elements to texted elements in video content **102**. The system includes a processor; and memory storing instructions that, when executed by the processor, cause the system to receive video content comprising a plurality of shots; generate a mapping between shots having similar shot durations in a plurality of shots within video content; identify, from the mapping, a first sequence of shots having a similar sequence duration to a second sequence of shots; determine the first sequence and the second sequence include matching content; and generate an indication that the first sequence and the second sequence are a pair of matching scenes.

In another aspect, the present technology relates to a computer-implemented method for automatically matching textless elements to texted elements in video content **102**, comprising: generating a mapping between shots having similar shot durations in a plurality of shots within video content; identifying, from the mapping, a first sequence of shots having a similar sequence duration to a second sequence of shots; determining the first sequence and the second sequence include matching content; and generating a list of pairs of matching scenes including the first sequence and the second sequence as a pair.

In another aspect, the present technology relates to a computer-readable medium storing instructions that, when executed by a computer, cause the computer to: generate a mapping between shots having similar shot durations in a plurality of shots within video content; identify, from the mapping, a first sequence of shots having a similar sequence duration to a second sequence of shots; select a representative frame included in the first sequence and a corresponding representative frame included in the second sequence; compare image content in the representative frames of the first sequence and the second sequence; determine the first sequence and the second sequence include matching content; and generate a list of pairs of matching scenes including the first sequence and the second sequence as a pair, wherein the first sequence includes a texted version of video content and the second sequence includes a textless version of the texted version of video content.

Aspects of the present invention, for example, are described above with reference to block diagrams and/or operational illustrations of methods, systems, and computer program products according to aspects of the invention. The functions/acts noted in the blocks may occur out of the order as shown in any flowchart. For example, two blocks shown in succession may in fact be executed substantially concurrently or the blocks may sometimes be executed in the reverse order, depending upon the functionality/acts involved. Further, as used herein and in the claims, the phrase "at least one of element A, element B, or element C" is intended to convey any of: element A, element B, element C, elements A and B, elements A and C, elements B and C, and elements A, B, and C.

The description and illustration of one or more examples provided in this application are not intended to limit or restrict the scope of the invention as claimed in any way. The aspects, examples, and details provided in this application are considered sufficient to convey possession and enable others to make and use the best mode of claimed invention. The claimed invention should not be construed as being limited to any aspect, example, or detail provided in this application. Regardless of whether shown and described in combination or separately, the various features (both structural and methodological) are intended to be selectively included or omitted to produce an example with a particular set of features. Having been provided with the description and illustration of the present application, one skilled in the art may envision variations, modifications, and alternate examples falling within the spirit of the broader aspects of the general inventive concept embodied in this application that do not depart from the broader scope of the claimed invention.

We claim:

1. A system comprising:

a processor; and

memory storing instructions that, when executed, perform operations comprising:

segmenting video content into a plurality of shots, each shot of the plurality of shots including a sequence of consecutive frames;

identifying, from a mapping between shots in the plurality of shots having similar shot durations within the video content, a first sequence of the shots having a similar sequence duration to a second sequence of the shots;

determining the first sequence and the second sequence include matching content; and

generating a list of matching scenes including the first sequence and the second sequence.

2. The system of claim **1**, wherein segmenting the video content into the plurality of shots comprises:

analyzing frames of the video content;

detecting shot transitions between the frames; and

determining which sequences of the frames are grouped as a shot.

3. The system of claim **1**, the operations further comprising:

generating an index including index values associated with each shot of the plurality of shots and a duration of each shot of the plurality of shots.

4. A method comprising:

generating a mapping between shots having similar shot durations within video content, wherein generating the mapping comprises:

analyzing frames of the shots;

detecting transitions between the frames; and

grouping sequences of the frames into individual shots of the shots;

identifying, from the mapping, a first sequence of the shots having a similar sequence duration to a second sequence of the shots;

determining the first sequence and the second sequence include matching content; and

generating a list of matching scenes including the first sequence and the second sequence.

5. The method of claim **4**, wherein the first sequence corresponds to a texted scene and the second sequence corresponds to a textless scene.

6. The method of claim **5**, wherein the second sequence is used to replace the first sequence in the video content.

7. A device comprising:

a processor; and

memory storing instructions that, when executed, perform operations comprising:

identifying, from a mapping between shots having similar shot durations within video content, a first sequence of shots having a similar sequence duration to a second sequence of shots, wherein the mapping indicates:

a number of shots in sequences of the video content; and

index values of the shots in the sequences;

determining the first sequence and the second sequence include matching content;

generating a list of matching scenes including the first sequence and the second sequence; and

editing the video content based on the list of matching scenes.

8. The system of claim **7**, wherein the index values include:

a first index value of a first shot in the first sequence; and

a second index value of a second shot in the second sequence, the first shot corresponding to the second shot.

9. The system of claim **7**, wherein the mapping further indicates at least one of;

a total duration of each of the first sequence and the second sequence; or

a confidence score that the first sequence and the second sequence are a matched pair.

10. A system comprising:

a processor, and

memory storing instructions that, when executed, perform operations comprising:

identifying, from a mapping between shots having similar shot durations within video content, a first sequence of the shots having a similar sequence duration to a second sequence of the shots, wherein the video content comprises:

texted content that includes a scene comprising text; and

textless content in which the text from the texted content has been removed from the scene;

determining the first sequence and the second sequence include matching content; and

generating a list of matching scenes including the first sequence and the second sequence.

11. The system of claim **10**, the operations further comprising:

generating the mapping by segmenting the video content into a plurality of shots each including a sequence of consecutive frames.

12. The system of claim **11**, wherein the mapping indicates:

a first index value of a first shot of the first sequence; and

a second index value of a first shot of the second sequence.

13. The system of claim **11**, wherein the mapping indicates:

a first total duration of the first sequence; and

a second total duration of the second sequence.

14. A system comprising:

a processor; and

memory storing instructions that, when executed, perform operations comprising:

identifying, from a mapping between shots having similar shot durations within video content, a first sequence of the shots having a similar sequence duration to a second sequence of the shots;

determining the first sequence and the second sequence include matching content, wherein the determining comprises:

selecting corresponding frames from the first sequence and the second sequence; and

comparing content of the corresponding frames using an image comparison metric, wherein text detected in the corresponding frames is ignored while comparing the content of the corresponding frames; and

generating a list of matching scenes including the first sequence and the second sequence.

15. The system of claim **14**, wherein the image comparison metric is Mean Squared Error.

16. A system comprising:

a processor; and

memory storing instructions that, when executed, perform operations comprising:

identifying, from a mapping between shots having similar shot durations within video content, a first sequence of the shots having a similar sequence duration to a second sequence of the shots;

determining the first sequence and the second sequence include matching content; and

generating a list of matching scenes including the first sequence and the second sequence, wherein each matched scene in the list of matching scenes includes an early sequence of shots including at least one texted frame and a late sequence of shots including at least one textless frame corresponding to the at least one texted frame.

17. The system of claim **16**, the operations further comprising:

providing the list of matching scenes to a video editor that replaces the at least one texted frame with the at least one textless frame.

18. The system of claim **17**, the operations further comprising:

replacing the at least one textless frame with at least one frame comprising text in a different language from text in the at least one texted frame.

19. A system comprising:

a processor; and

memory storing instructions that, when executed, perform operations comprising:

receiving the video content at a video processing device for matching textless content to texted content in the video content, the video processing device comprising a video editor;

identifying, from a mapping between shots having similar shot durations within video content, a first sequence of the shots having a similar sequence duration to a second sequence of the shots;

determining the first sequence and the second sequence include matching content;

generating a list of matching scenes including the first sequence and the second sequence; and

using the video editor to modify the video content based on the list of matching scenes.

20. The system of claim **19**, wherein using the video editor to modify the video content comprises replacing at least a portion of the texted content with at least a portion of the textless content.

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