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(54) **ENHANCING MEDIA CONTENT EFFECTIVENESS USING FEEDBACK BETWEEN EVALUATION AND CONTENT EDITING**

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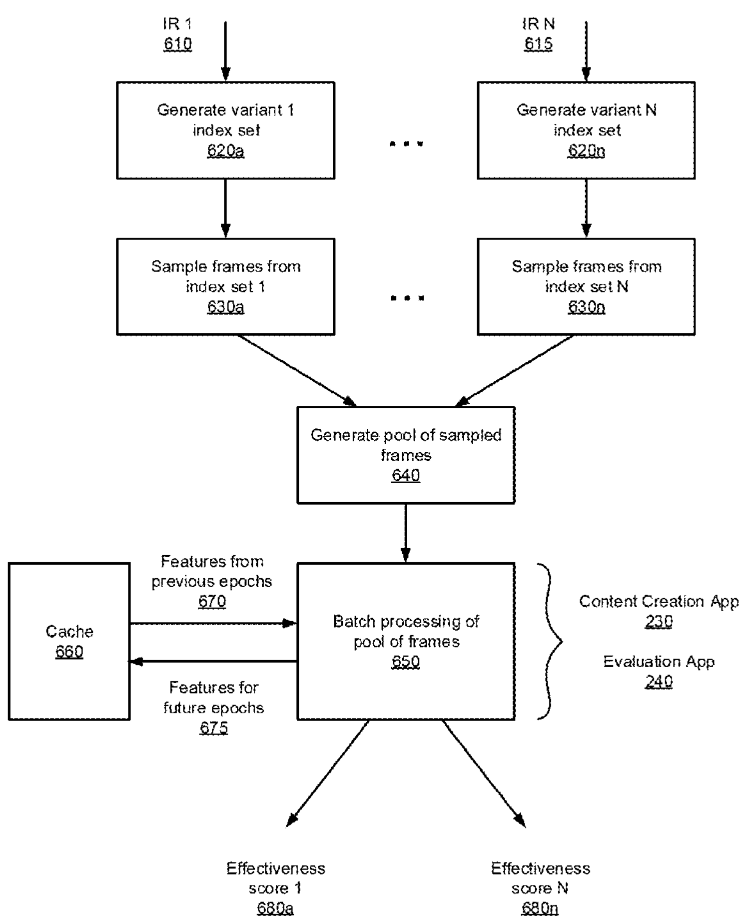
(57) **ABSTRACT**

Techniques are disclosed for improving media content effectiveness. A methodology implementing the techniques according to an embodiment includes generating an intermediate representation (IR) of provided media content, the IR specifying editable elements of the content and maintaining a result of cumulative edits to those elements. The method also includes editing the elements of the IR to generate a set of candidate IR variations. The method further includes creating a set of candidate media contents based on the candidate IR variations, evaluating the candidate media contents to generate effectiveness scores, and pruning the set of candidate IR variations to retain a threshold number of the candidate IR variations as surviving IR variations associated with the highest effectiveness scores. The process iterates until either an effectiveness score exceeds a threshold value, the incremental improvement at each iteration falls below a desired value, or a maximum number of iterations have been performed.

Batch Processing Implementation
600



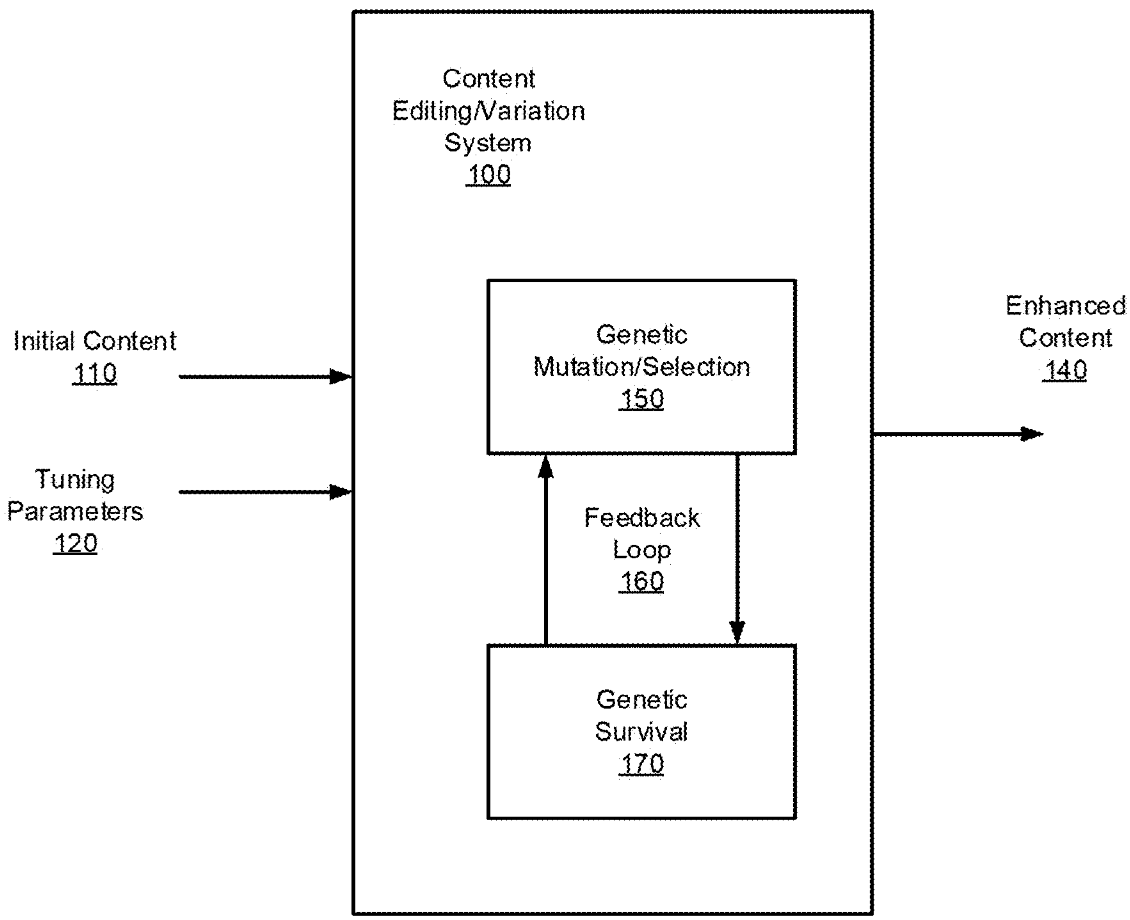

Content
Editing/Variation
System
100
Initial Content
110
Tuning
Parameters
120
Genetic
Mutation/Selection
150
Feedback
Loop
160
Genetic
Survival
170
Enhanced
Content
140

FIG. 1

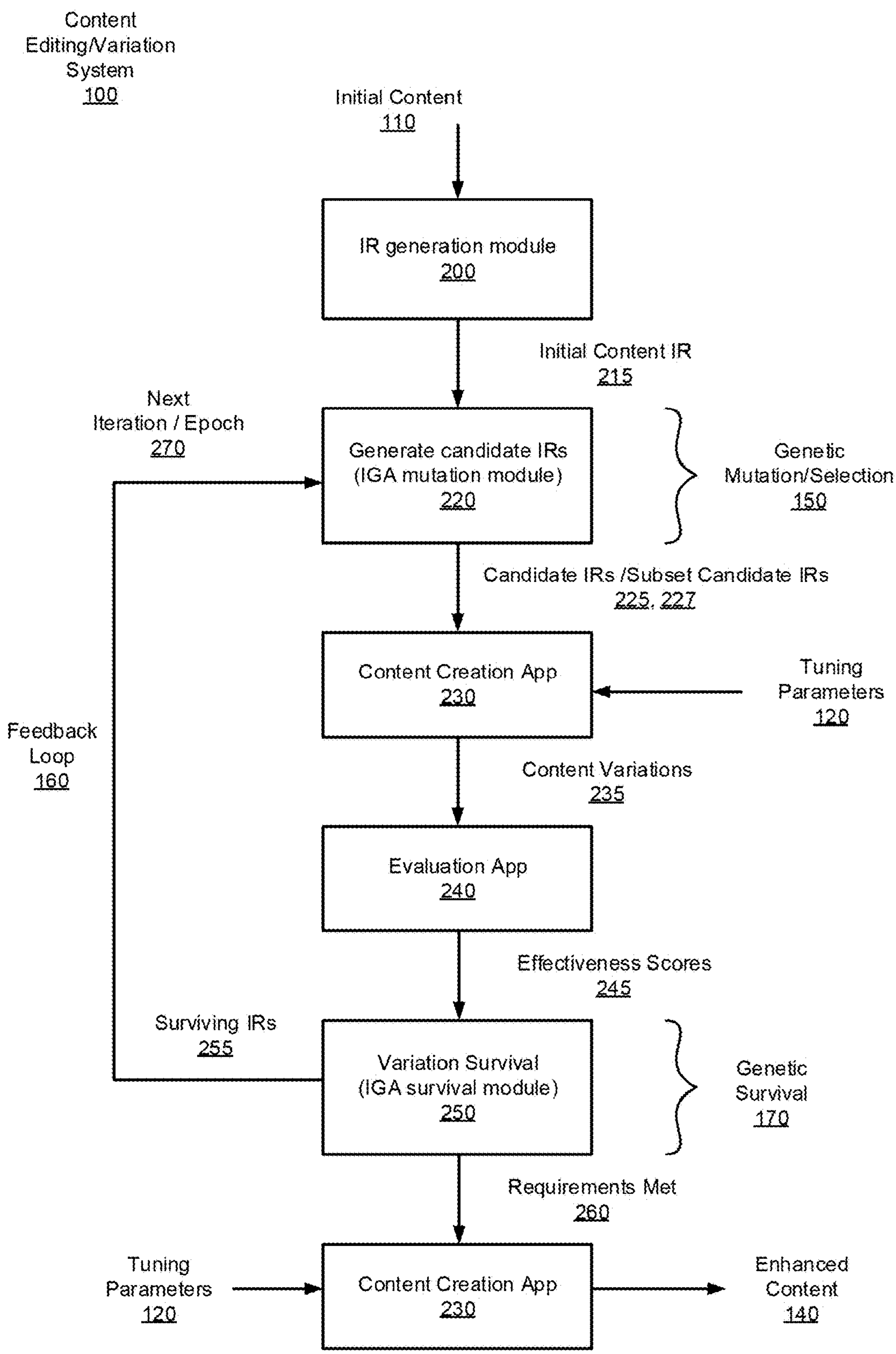

Content Editing/Variation System 100
Initial Content 110
IR generation module 200
Initial Content IR 215
Next Iteration / Epoch 270
Generate candidate IRs (IGA mutation module) 220
Genetic Mutation/Selection 150
Candidate IRs /Subset Candidate IRs 225, 227
Content Creation App 230
Tuning Parameters 120
Feedback Loop 160
Content Variations 235
Evaluation App 240
Effectiveness Scores 245
Surviving IRs 255
Variation Survival (IGA survival module) 250
Genetic Survival 170
Requirements Met 260
Tuning Parameters 120
Content Creation App 230
Enhanced Content 140

FIG. 2

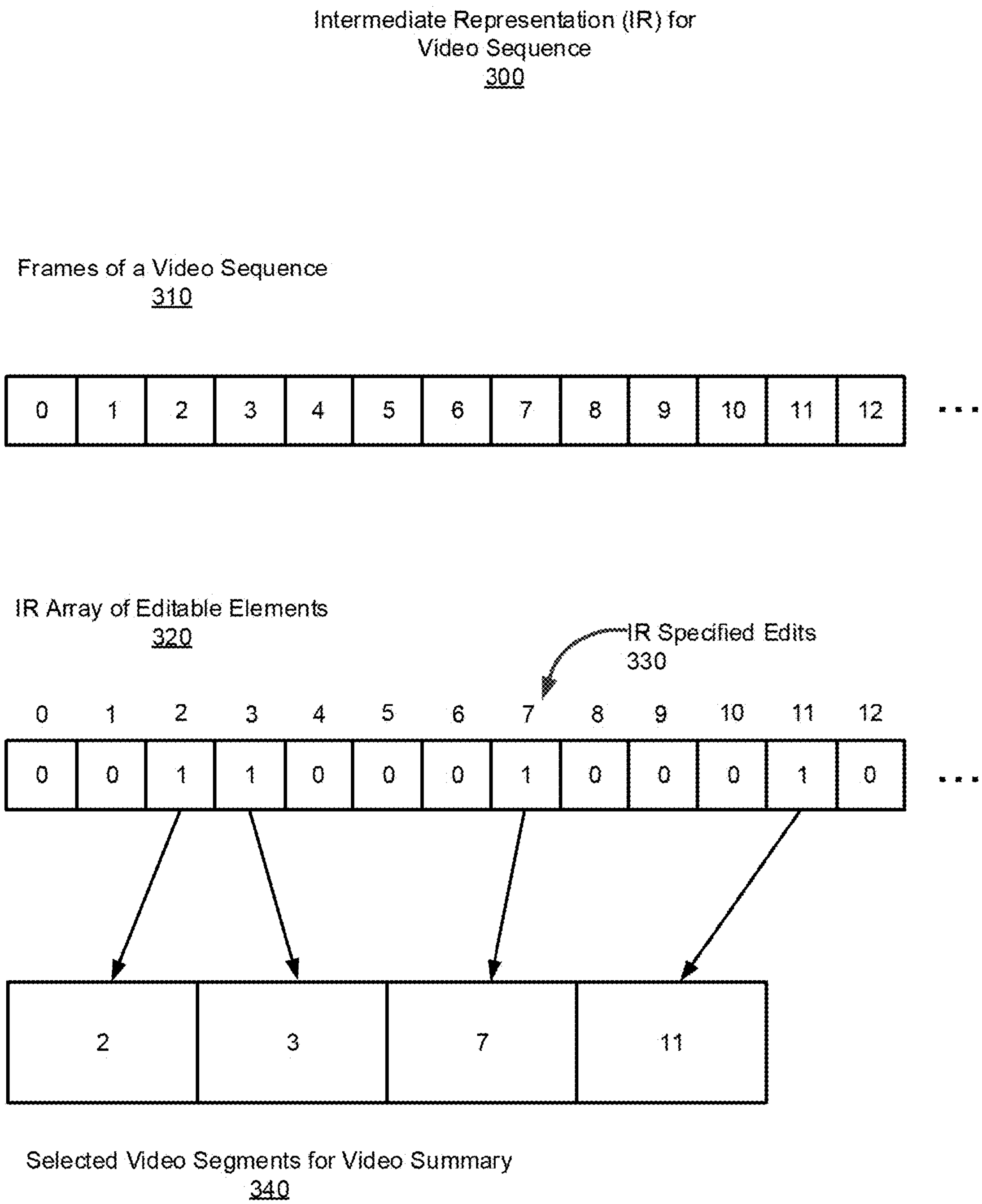

Intermediate Representation (IR) for Video Sequence
300
Frames of a Video Sequence
310
0 1 2 3 4 5 6 7 8 9 10 11 12 ...
IR Array of Editable Elements
320
IR Specified Edits
330
0 1 2 3 4 5 6 7 8 9 10 11 12
0 0 1 1 0 0 0 1 0 0 0 1 0 ...
2 3 7 11
Selected Video Segments for Video Summary
340

FIG. 3

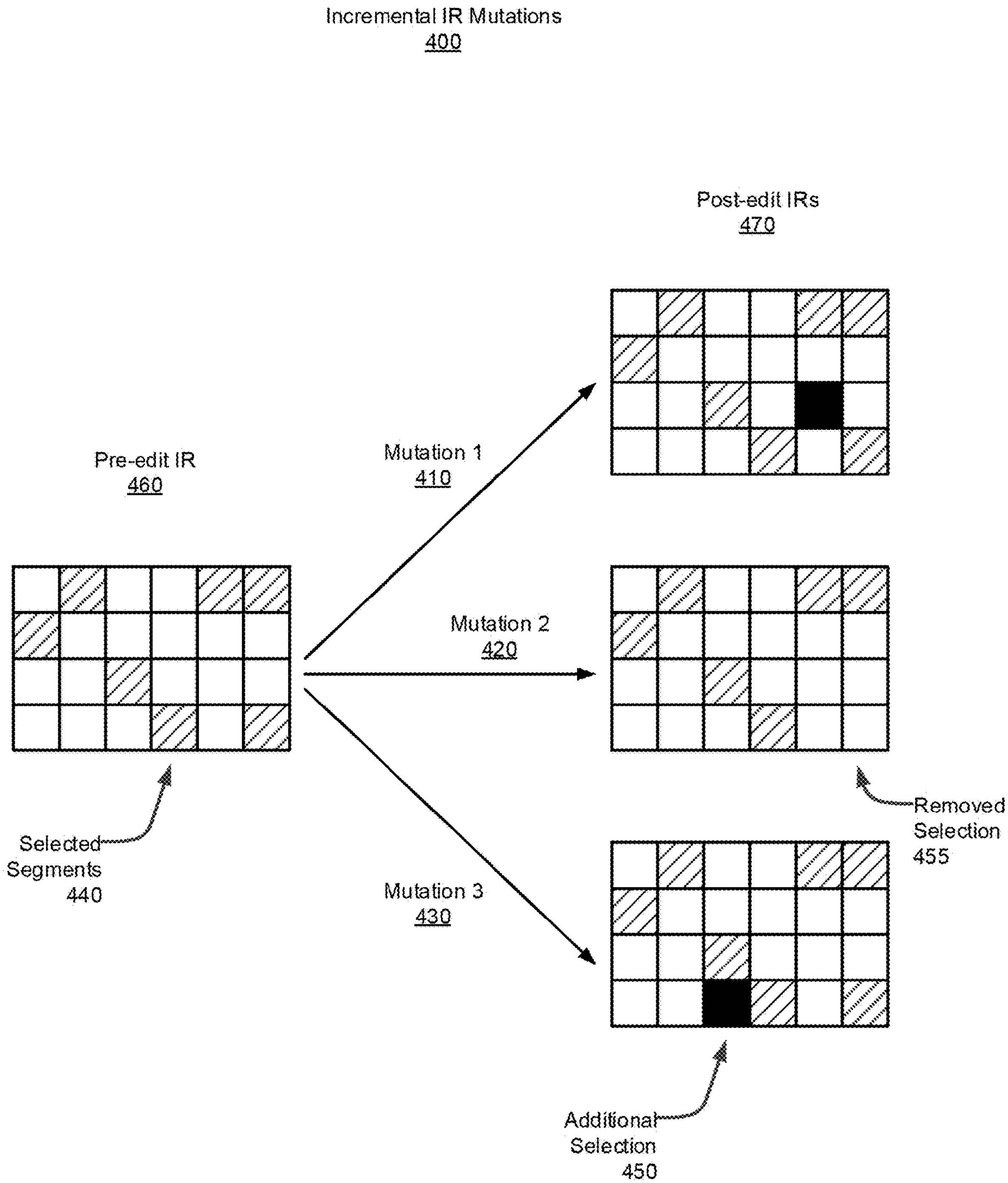

Incremental IR Mutations
400
Post-edit IRs
470
Pre-edit IR
460
Mutation 1
410
Mutation 2
420
Mutation 3
430
Selected Segments
440
Removed Selection
455
Additional Selection
450

FIG. 4

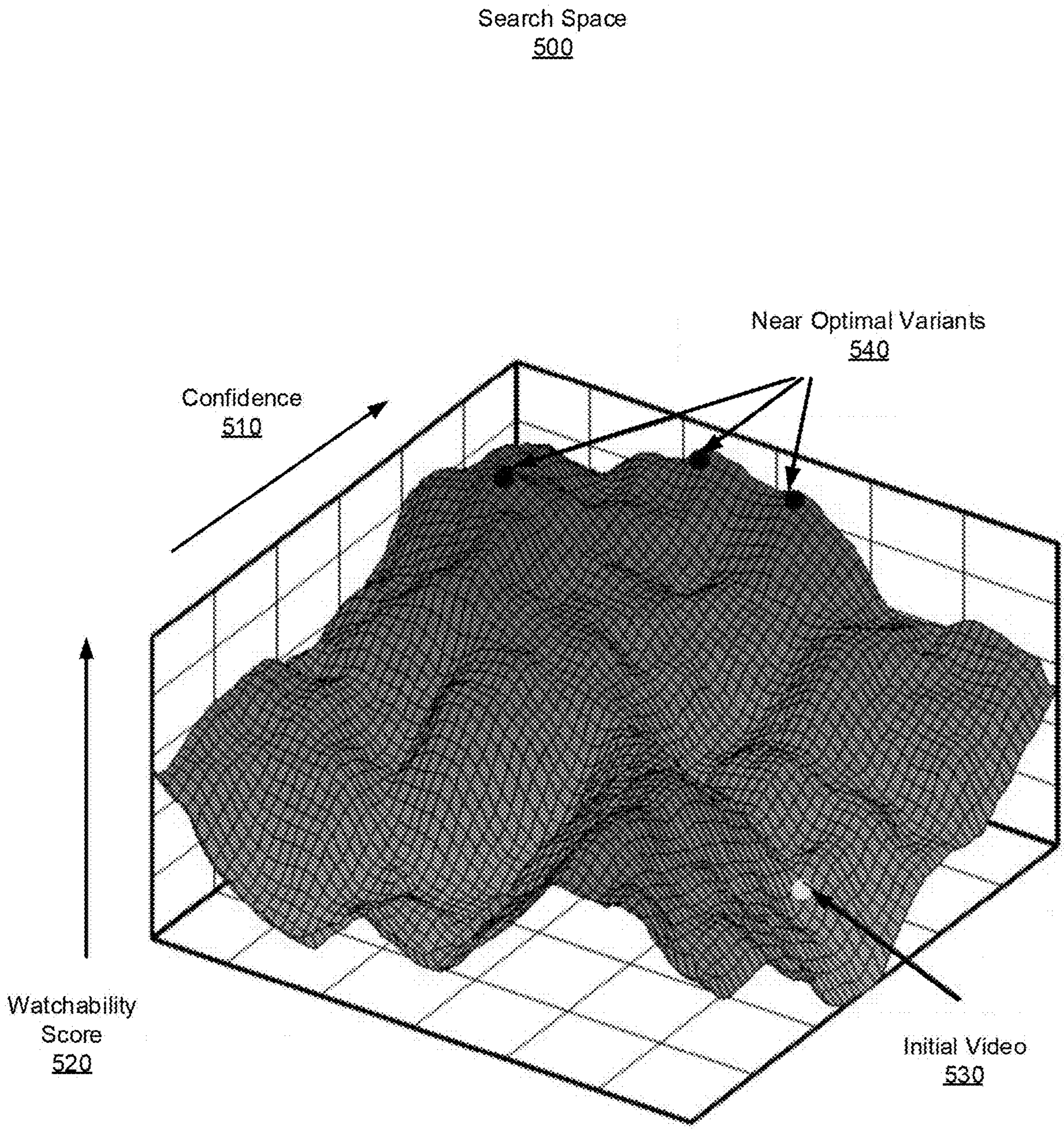

Search Space
500
Near Optimal Variants
540
Confidence
510
Watchability
Score
520
Initial Video
530

FIG. 5

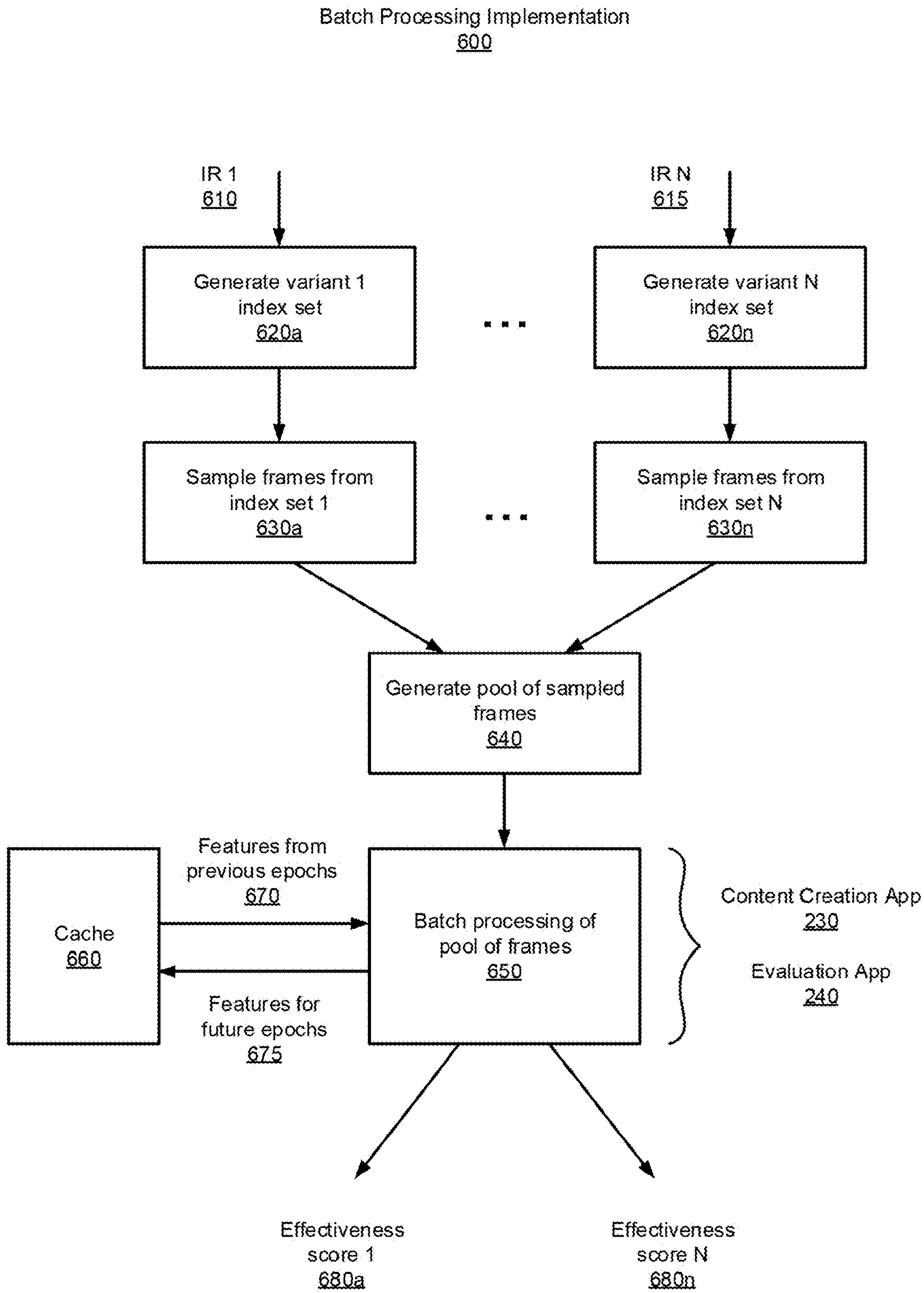

Batch Processing Implementation
600
IR 1
610
IR N
615
Generate variant 1 index set
620a
Generate variant N index set
620n
Sample frames from index set 1
630a
Sample frames from index set N
630n
Generate pool of sampled frames
640
Cache
660
Features from previous epochs
670
Features for future epochs
675
Batch processing of pool of frames
650
Content Creation App
230
Evaluation App
240
Effectiveness score 1
680a
Effectiveness score N
680n

FIG. 6

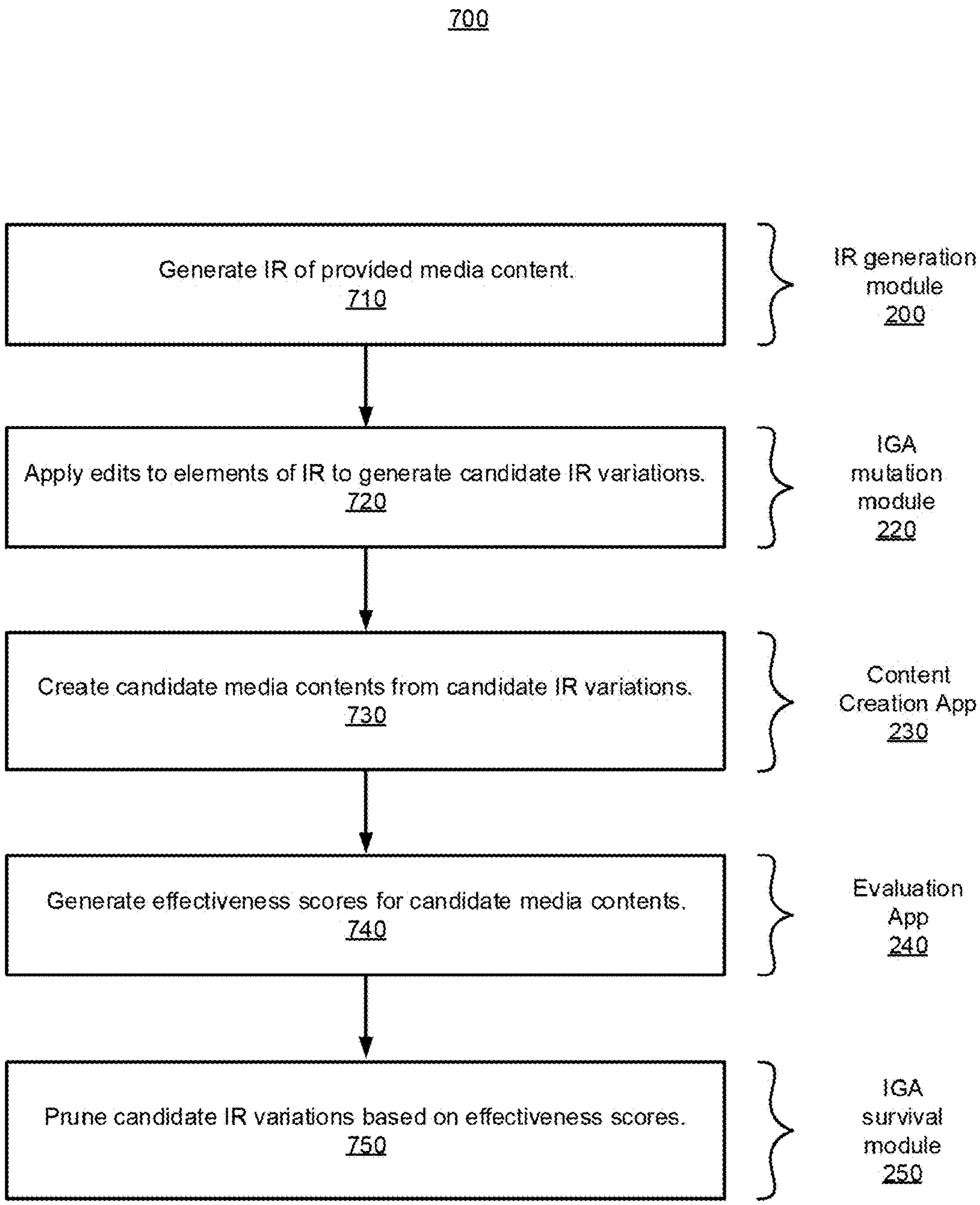

700
Generate IR of provided media content.
710
IR generation module
200
Apply edits to elements of IR to generate candidate IR variations.
720
IGA mutation module
220
Create candidate media contents from candidate IR variations.
730
Content Creation App
230
Generate effectiveness scores for candidate media contents.
740
Evaluation App
240
Prune candidate IR variations based on effectiveness scores.
750
IGA survival module
250

FIG. 7

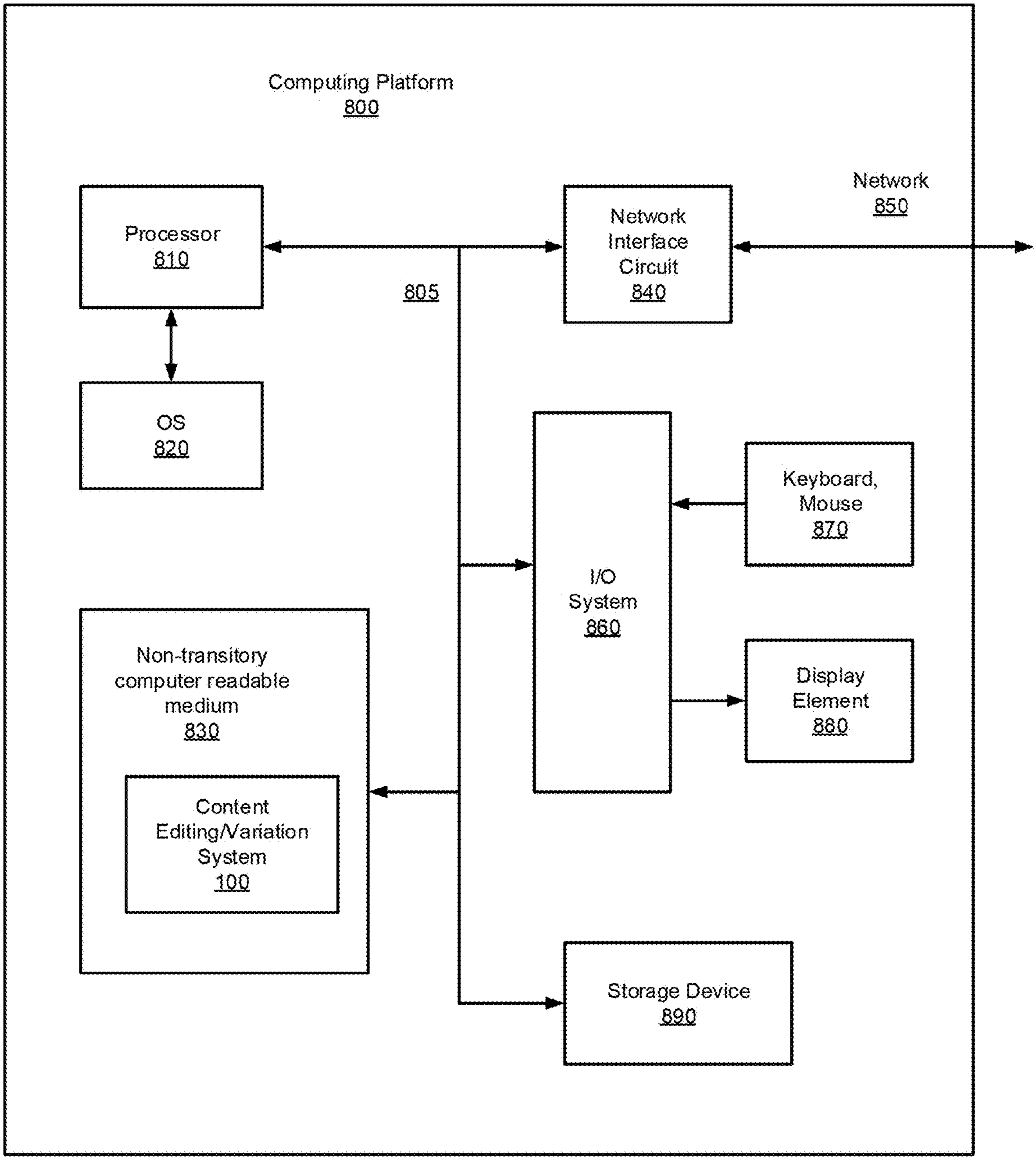

Computing Platform 800
Processor 810
805
Network Interface Circuit 840
Network 850
OS 820
I/O System 860
Keyboard, Mouse 870
Display Element 880
Non-transitory computer readable medium 830
Content Editing/Variation System 100
Storage Device 890

FIG. 8

ENHANCING MEDIA CONTENT EFFECTIVENESS USING FEEDBACK BETWEEN EVALUATION AND CONTENT EDITING

FIELD OF THE DISCLOSURE

[0001] This disclosure relates to improvement of media content effectiveness. Particularly, this disclosure relates to systems and methods employing feedback between content evaluation and content editing for improvement of media content effectiveness.

BACKGROUND

[0002] Digital media content is ubiquitous in the current information age and audiences can be presented with an enormous amount of content. As such, it becomes increasingly important to create personalized and effective content that draws the attention of the viewer/listener and conveys the intended message effectively. Creators of digital media content typically rely on their own expertise, experience, and personal preferences, in the composition, editing, and evaluation process, to maximize the effectiveness of the resulting content for the chosen publishing platform. The results may be sub-optimal, however, because the experience of the content creators can be biased or inaccurate in some cases, and it is generally difficult to predict the effectiveness of any given variation, or sequence of variations, of the media content (e.g., how positively an audience may react to the content). Moreover, the process of creating effective content variations for different publishing platforms and audiences can be time-consuming, tedious, and expensive, which does not lend itself to scalability. In short, such artist/creator-based content creation processes tend to be inefficient, so technical solutions to assist artists/creators are needed. Unfortunately, the currently available technical solutions for more efficiently creating more impactful content variations are inadequate, as the editing process is not guided by what is known or otherwise inferable, as will be explained in turn.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. **1** is a top-level block diagram of a content editing/variation system for improving media content effectiveness, configured in accordance with an embodiment of the present disclosure.

[0004] FIG. **2** is a more detailed block diagram of the content editing/variation system, configured in accordance with an embodiment of the present disclosure.

[0005] FIG. **3** illustrates one example of an intermediate representation, in accordance with an embodiment of the present disclosure.

[0006] FIG. **4** illustrates incremental intermediate representation mutations, in accordance with an embodiment of the present disclosure.

[0007] FIG. **5** illustrates a search space over which the content editing/variation system operates, in accordance with an embodiment of the present disclosure.

[0008] FIG. **6** illustrates a batch processing implementation of the content editing/variation system, configured in accordance with an embodiment of the present disclosure.

[0009] FIG. **7** is a flowchart illustrating a method for improving media content effectiveness, in accordance with an embodiment of the present disclosure.

[0010] FIG. **8** is a block diagram schematically illustrating a computing platform configured to perform any of the techniques as variously described in this disclosure, configured in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0011] Techniques are disclosed for improving media content effectiveness. This improvement is enabled by providing a feedback loop between the automated content editing and the data-driven performance evaluation of content. In more detail, a methodology implementing the techniques according to one example embodiment includes generating an intermediate representation of provided media content. The intermediate representation specifies editable elements of the content and maintains a result of cumulative edits to those elements. The method also includes editing the elements of the intermediate representation to generate a set of candidate intermediate representation variations, and optional pruning or pre-selecting of the candidate intermediate representation variations to generate a subset of candidate intermediate representation variations. In some embodiments, the pre-selection operation may be omitted, for example if sufficient computing power is available to consider all candidate intermediate representations. The method further includes creating a set of candidate media contents based on the candidate intermediate representation variations (or subset thereof), and evaluating the candidate media contents to generate effectiveness scores, for example based on performance/analytics data as will be explained later. The candidate intermediate representation variations are then pruned to retain a threshold number of the candidate intermediate representation variations as surviving intermediate representation variations associated with the highest effectiveness scores. The process can iterate until either an effectiveness score exceeds a threshold value, the incremental improvement in effectiveness scores falls below a threshold value, or the number of iterations exceeds a maximum limit. Thus, data-driven editing recommendations are provided to the artist. Because the feedback loop between the automated content editing and the data-driven performance evaluation of content is closed, the resulting creations have a higher probability of being positively impactful to a target audience. Numerous configurations and embodiments will be appreciated in light of this disclosure.

[0012] General Overview

[0013] As noted previously, the available technical solutions for more effectively creating content are inadequate. For instance, one possible technical solution is to evaluate the effectiveness of a creative content based on historical user behavioral or content performance data. However, such approaches do not provide editing recommendations to boost-up the content effectiveness. In other words, only the performance of existing content is predicted, and the editing process is independent and devoid of any guidance on performance. Another possible technical solution is to automatically generate and/or edit the content based on only a few user inputs, such as automatic video summarization. But the editing decisions from such techniques are not associated with the performance data and are not so straightforward that they can be readily applied to increase the effectiveness of content. In short, such technical solutions fail to establish a feedback loop between the automated content editing and the data-driven performance evaluation of content. For example, consider that case where LSTM-based techniques are used to summarize the video in a both supervised and unsupervised way. Such an approach aims to optimize the content creation based on aesthetical aspects and/or expert editing choices solely and does not take performance data into account to improve content effectiveness. In a further example, consider the case where an LSTM-based model is trained on short video ads based on its effectiveness ratings. Even though performance data is used to generate the evaluation, it is not easy or otherwise intuitive to derive what actions should be taken in order to further improve the content performance. Thus, and as will be appreciated in light of this disclosure, a technical solution to automatically generate data-driven editing recommendations to maximize or otherwise improve the performance of the resulting content is currently missing. As such, an improved technical solution is needed.

[0014] Thus, techniques are provided herein for generating data-driven editing recommendations to improve the performance of the resulting content. The techniques are an improvement over existing technical solutions, which fail to provide a feedback loop between the automated content editing and the data-driven performance evaluation of content. By providing such valuable feedback, the techniques disclosed herein enable data-driven automated content editing/variant creation to improve performance (effectiveness) of content. So, according to an embodiment of the present disclosure, a methodology is provided for the creation of media content variations. The methodology employs a feedback loop between content evaluation and content editing. In some embodiments, the feedback loop between editing and evaluation is based on an incremental and iterative genetic search technique. The genetic search technique employs edits (e.g., genetic mutations), random selection of the mutations, and pruning based on evaluation of the results (e.g., genetic survival), over a number of iterations, as will be described in greater detail below. Additionally, in some such example embodiments, an intermediate representation of the media content (and variations generated therefrom) is employed as an abstraction of the editing operations that are performed on the content. In more detail, the intermediate representation may specify the editable elements of the media content and maintain a result of cumulative edits that have been performed on those elements, according to an embodiment. The use of an intermediate representation in place of the actual content allows for a more efficient genetic search, as will be described in greater detail below. Many variations and embodiments will be appreciated in light of this disclosure.

[0015] Framework and System Architecture

[0016] FIG. **1** is a top-level block diagram of a content editing/variation system **100** for improving media content effectiveness, configured in accordance with an embodiment of the present disclosure. The content editing/variation system **100** is configured to find a near-optimal content variation, based on predicted performance of the content, using a feedback-based incremental genetic search technique. The content editing/variation system **100** is provided with the initial media content **110** (and in some embodiments, tuning parameters **120**, to be described later). The system performs an incremental iterative search process starting from the initial content **110**. As can be seen, the search process comprises genetic mutation and selection **150** and genetic survival **170** configured in a feedback loop **160**. The iterative search continues until either a selected measure of content effectiveness is achieved, incremental improvement in effectiveness falls below a threshold value, or a maximum number of iterations has occurred, at which point the enhanced content **140** is presented as the result.

[0017] In more detail, in an example use case, the media content may be a video stream comprising a sequence of video frames, and the goal is to produce a video summarization that includes a subset of the video frames and which achieves a target effectiveness score (e.g., an indication of how watchable or well received the video will be). The intermediate representation (IR) in this case can be an array of binary values, wherein each element of the array is associated with one frame of the original video stream, and the binary values indicate the presence or absence of that frame in the resulting video summary. Edits or mutations can toggle the elements of the IR array to cause frames to be included or removed from the video summarization. Any desired number of candidate IR variations may be generated in this manner and, in some embodiments, pruned back through random selection to generate a subset of candidate IR variations to conserve computing resources. The candidate IR variations (or the pruned subset) can then be evaluated to generate effectiveness scores, using any desired video evaluation technique, in light of the present disclosure, and the candidate IR variations can then be further pruned to retain only those surviving variations associated with the highest effectiveness scores. The process can be iterated until one of the surviving variations achieves an effectiveness score that meets a desired threshold, the incremental improvement in effectiveness scores falls below a threshold value, or the number of iterations exceeds a maximum limit. That surviving IR variation can then be used to generate the summarization video, with near-optimal content effectiveness, by specifying the frames that should be used. Note that the use of "near-optimal" herein is not intended to implicate near-perfect or an otherwise exceedingly high level of effectiveness on a target audience; rather, near-optimal is merely intended to refer to an effectiveness level that has a high probability to be acceptable because of the feedback loop provided herein. So, for instance, an editorial recommendation produced by the methodology is likely to produce content that will be sufficiently impactful on a target audience in a positive manner (e.g., the content will cause click-throughs at a rate of **20**% or higher). To this end, the present disclosure is not intended to be limited to precise levels of effectiveness or impactfulness on a given audience.

[0018] In another example use case, the media content may be a segment of text (e.g., a description of a product of the website), and the goal is to produce a modified text segment, based on some subset of the words in the original text segment, to provide a more effective message. For example, the text may need to be summarized to a shorter length for a specific social media channel, compared to the length that is suitable for a product website. Here again, the IR can be an array of binary values, wherein each element of the array is associated with one word of the original text, and the binary values indicate the presence or absence of that word in the resulting modified text. Edits or mutations can toggle the elements of the IR array to cause words to be included or removed from the modified text. The process may proceed in a manner analogous to that described above for video summarization, using genetic mutation, random selection, and genetic survival over some number of iterations to generate a modified text segment with an effectiveness score that reaches a desired threshold. Other text-based examples include customizing the language and style of a product description to better target a specific audience (e.g., teenage versus adult).

[0019] In still another example use case, the media content may be an image, and the goal is to produce a modified image that is more engaging to a particular audience or is more likely to be licensed on an image repository web site. Here, the IR can be an array of imaging parameters, such as, for example, color saturation, contrast, brightness, etc. The process is similar to those described above for video summarization and text manipulation, but the edits or mutations are performed on the imaging parameters to create variations of the image for genetic processing to produce an enhanced image. In still another example use case, the media content may be a three-dimensional augmented reality scene, in which objects in the scene may be modified in some manner to increase effectivenenss. It will be appreciated that numerous other applications and example use cases are possible in light of the present disclosure.

[0020] In more detail, according to an embodiment, a methodology implementing the techniques for improving the effectiveness of media content includes the following. Generating an IR of a provided media content such as, for example, a video stream, a three-dimensional augmented reality scene, an image, a graphic (e.g., an icon, or custom piece of art, or other creation) an audio stream, a segment of text, or any combination of these. The IR is configured to specify editable elements of the media content and to maintain a result of cumulative edits to the editable elements. Editable elements may include, for example, a frame of the video stream, a characteristic of the image (e.g., color saturation, etc.), a segment of the audio stream, or individual words or phrases of the text segment. The method also includes applying edits to one or more of the editable elements of the IR to generate a set of candidate IR variations. Edits may include, for example, adding or removing one or more video frames to/from the video stream, changing image characteristics, adding or removing segments of the audio stream, and adding or removing one or more words of the segment of text. In some embodiments, the method further includes an optional pruning or pre-selecting operation to be performed on the set of candidate IR variations to generate a subset of candidate IR variations, for example, based on a random selection process. The pre-selection operation may be omitted, for example if sufficient computing power is available to consider all candidate intermediate representations. The method further includes executing a content creation application to create a set of candidate media contents based on the candidate IR variations (or subset thereof) and executing a content evaluation application to generate effectiveness scores for the set of candidate media contents. The method further includes pruning the candidate IR variations to retain a threshold number of the candidate IR variations with the highest effectiveness scores as surviving IR variations. These operations are iterated on the surviving IR variations until one of the effectiveness scores reaches a threshold value, the incremental improvement in effectiveness scores falls below a threshold value, or the number of iterations exceeds a maximum limit. After the iterations terminate, the content creation application may be executed again to create a resulting media content variation based on the surviving IR variation associated with the effectiveness score that exceeded the threshold value, i.e., the most effective content variation.

[0021] Thus, the foregoing framework provides a system and methodology for improving the effectiveness of media content using feedback between evaluation and content editing. Numerous example configurations and variations will be apparent in light of this disclosure.

[0022] FIG. **2** is a more detailed block diagram of the content editing/variation system **100**, configured in accordance with an embodiment of the present disclosure. The content editing/variation system **100** is shown to include an IR generation module **200**, an IGA mutation/selection module **220**, a content creation application **230**, a content evaluation application **240**, and an IGA survival module **250**. The operation of each of these modules will be described in detail below, but at a high level, the operations can be summarized as follows. First, initial media content that is provided to the system is transformed into an IR. Next, a genetic search (including mutation, selection, and survival operations) is performed in an iterative manner until either threshold requirements of media effectiveness are met, improvement falls below a desired level, or an iteration limit has been exceeded. An example search space is illustrated in FIG. **5** and described in more detail below. Finally, a resulting enhanced media content is produced using the results of the search.

[0023] In more detail, the IR generation module **200** is configured to generate an initial IR **215** based on the initial media content **110** that is provided to the system. Media content, such as an image or video, tends to be large in size and typically requires significant computation to generate features that models can work with. The IR is a more efficient representation of that media content that works well with genetic search techniques as described herein. IRs are used to represent intermediate states associated with the content variations that are generated and operated upon during the genetic search process for creating more effective media content. For example, as illustrated in FIG. **3**, media content in the form of a video comprises a sequence of frames **310**. The IR **300** can be stored as an array or vector of binary editable elements **320**, each element corresponding to one video frame. The binary value can be set to a one to indicate that the corresponding video frame is selected for use in a video summary **340**, or it can be set to a zero to indicate that the video frame will not be used. Each adjustment of an editable element of the IR corresponds to an IR specified edit or mutation **330**.

[0024] At any point in time, the IR provides an indication of the accumulation of edits that have occurred over all the iterations that have occurred up to that time. So, for example, on the first iteration, element **2** may have been set to a 1 and the IR would read 0010000000000. On the second iteration, element **7** may have been set to a 1 and the IR would be updated to 0010000100000. At some iteration, element **4** may be set to a 1, and at a later iteration that element may be set back to a 0, but the IR will maintain the most current state of the element at a given point in time. So, in this case element **4** is 0 to reflect the most recent edit.

[0025] The IGA mutation/selection module **220** is configured to apply edits (e.g., mutations) to one or more of the editable elements of an IR to generate a set of candidate IR variations **225**. Edits may include, for example, adding or removing one or more video frames to/from a video stream, changing image characteristics, adding or removing segments of an audio stream, and adding or removing one or more words of a segment of text. On the first iteration, the IR will be the initial content IR **215**, while on subsequent iterations, the IR will be the surviving IRs **255** (as described below).

[0026] In some embodiments, each of the candidate IR variations **225** results from the application of a single edit that is performed on the IRs (**215** or **255**) during that iteration. This "incremental" approach allows for the observation of the effects of one editing step on the performance of the newly generated content variation. This can aid content creators and provide guidance as to which edits tend to maximize the effectiveness of the media content. Examples of incremental IR mutations **400** are illustrated in FIG. **4**, in accordance with an embodiment of the present disclosure. A pre-edit IR **460** is shown to include selected segments **440** indicated with hash marks (e.g., elements of the array set to **1**). Three separate incremental mutations **410**, **420**, **430** are shown resulting in post-edit IRs **470**, each containing either one new additional selection **450** or a removed selection **455**.

[0027] In some embodiments, all possible edits may be performed. There are N possible incremental edits on an IR array of length N. In other embodiments, a subset of all possible edits may be performed, the subset being chosen randomly or through any desired method.

[0028] In some embodiments, the IGA mutation/selection module **220** is also configured to prune the set of candidate IR variations **225** to generate a subset of candidate IR variations **227**. The pruning may be based on a random selection process.

[0029] The content creation application **230** is configured to create a set of candidate media content variations **235** based on the candidate IR variations **225** or **227**. Said differently, the content creation application **230** transforms the intermediate representation of the variations back into media content variations, which is the format most suitable for content evaluation, as described below. For example, in the case of a video sequence summarization, the content creation application **230** splices together the video frames that are specified for inclusion by the candidate IR variations. In some embodiments, the content creation application **230** may be implemented as a neural network. In some embodiments, the content creation application **230** accepts tuning parameters **120** that can guide the content creation process based on user preferences. Examples of tuning parameters may include a desired duration of the resulting video, a contrast or color saturation parameter for the resulting image, a preference for people versus scenery in an image, etc. These are just 3 examples, but any conceivable tuning parameter may be used.

[0030] The content evaluation application **240** is configured to generate effectiveness scores **245** for the set of candidate media content variations **235**. In some embodiments, the content evaluation application also generates a confidence value associated with the effectiveness score to provide an indication of how accurate the score may be. For instance, a relatively high score coupled with a low confidence value may not rank as highly as a somewhat lower score coupled with a high confidence value. The content evaluation application **240** may use any desired techniques, in light of the present disclosure, to evaluate the effectiveness of the media content, for example, based on existing performance/analytics data. For example, in the case of a video, the score may indicate the "watchability" of the video (e.g., the ability of the video to hold the viewer's interest). In some embodiments, the content evaluation application **240** may be implemented as a neural network.

[0031] The IGA survival module **250** is configured to prune the candidate IR variations **225** or **227** to retain a selected number of the candidate IR variations as surviving IR variations **255**. The pruning is based on the effectiveness scores **245** (or a combination of effectiveness scores and confidence values) such that the surviving IR variations **255** are associated with the highest effectiveness scores (possibly weighted by confidence values).

[0032] The process then iterates, using the surviving IRs **255** in a feedback loop **162** be provided to IGA mutation module **220** for the next iteration or epoch **270**. The iteration continues through succeeding epochs until a desired requirement **260** is met. In some embodiments, this requirement may be expressed as an effectiveness score threshold value. If and when the effectiveness score (or effectiveness score plus confidence value) exceeds that threshold, a satisfactory content variation has been achieved. The content creation application **230** may then be executed to create a final media content variation result (i.e., the enhanced content **140**) based on the surviving IR variation that is associated with the effectiveness score that exceeded the threshold value.

[0033] In some embodiments, if the threshold is not met after a selected maximum number of iterations has occurred, the process may be terminated. This condition may indicate a failure to find a satisfactory content variation.

[0034] In some embodiments, a history of the candidate IR variations is maintained over all the iterations. The history is used to reject any new candidate IR variation resulting from mutations that matches an entry in the history, thus ensuring that an IR is visited at most once during the search process. This serves to prevent the process from getting stuck in an infinite loop in which the search repeatedly loops back on itself

[0035] FIG. **5** illustrates a search space **500** over which the content editing/variation system **100** operates, in accordance with an embodiment of the present disclosure. The search space **500** is represented as a 3-dimensional surface. The initial video is located at a point **530** in the space that is associated with a relatively low watchability score **520** and confidence **510**. As the genetic search proceeds, however, the mutations should eventually steer the variations towards one of the points **540** associated with near optimal variations of the video, in terms of confidence **510** and watchability score **520**.

[0036] FIG. **6** illustrates a batch processing implementation **600** of the content editing/variation system **100**, configured in accordance with an embodiment of the present disclosure. In general, the content creation application **230**, and the evaluation application **240** tend to consume the greatest share of computing resources in the content editing/variation system **100**. In some embodiments, therefore, inefficiency can be obtained by performing batch processing. For example, in the context of a video sequence, multiple IRs are generated (IR **1** **610** through IR N **615**). At operations **620**(*a-n*), sets of indices are generated for each of the N variations. At operations **630**(*a-n*), frames of the video are sampled based on the sets of indices, and at operation **640**, a pool or batch of the sampled frames is generated. Then, at operation **650**, batch processing (e.g., execution of the content creation app **230** and the evaluation at **240**) is performed on the pool of frames to generate effectiveness scores 1 through N **680**(*a-n*). Batch processing takes advantage of the fact that there is likely to be duplication of frames in each of the IRs, and so the computationally intensive applications **230** and **240** do not need to be executed multiple times on those frames.

[0037] In some embodiments, additional efficiency can be achieved by maintaining a cache **660** to store feature vectors that are typically generated by the evaluation application **240**. These features can then be reused on a subsequent iteration. Thus, the batch processing operation **650** can employ the features **670** that were stored from previous epochs, and save new features **675** for future epochs.

[0038] Methodology

[0039] FIG. **7** is a flowchart **700** illustrating a method for improving media content effectiveness, in accordance with an embodiment of the present disclosure. As can be seen, the method is described with reference to the configuration of feedback-based content editing/variation system **100** of FIGS. **1**, **2**, and **6**. However, any number of module configurations can be used to implement the method, as will be appreciated in light of this disclosure. Further note that the various functions depicted in the method do not need to be assigned to the specific example modules shown. To this end, the example methodology depicted is provided to give one example embodiment and is not intended to limit the methodology to any particular physical or structural configuration; rather, the feedback-based techniques provided herein can be used with a number of architectures and platforms and variations, as will be appreciated.

[0040] The method commences, at operation **710**, by generating an IR of a provided media content. In some embodiments, the media content may be a video stream, an image, an audio stream, or a segment of text. The IR is configured to specify editable elements of the media content and to maintain a result of cumulative edits to the editable elements. Editable elements may include, for example, a frame of the video stream, a characteristic of the image (e.g., color saturation, etc.), a segment of the audio stream, or individual words or phrases of the text segment.

[0041] The method continues, at operation **720**, by applying edits to one or more of the editable elements of the IR to generate a set of candidate IR variations. Edits may include, for example, adding or removing one or more video frames to/from the video stream, changing image characteristics, adding or removing segments of the audio stream, and adding or removing one or more words of the segment of text.

[0042] At operation **730**, a content creation application is executed to create a set of candidate media contents based on the candidate IR variations. In some embodiments, the content creation application may be implemented as a neural network.

[0043] At operation **740**, a content evaluation application is executed to generate effectiveness scores for the set of candidate media contents. In some embodiments, the content evaluation application may be implemented as a neural network. In some embodiments, the effectiveness score may include a confidence value.

[0044] At operation **750**, the candidate IR variations are pruned to retain a threshold number of the candidate IR variations as surviving IR variations, the surviving IR variations associated with the highest effectiveness scores.

[0045] In some embodiments, additional operations are performed. For example, in one embodiment, operations **720** through **750** are iterated on the surviving IR variations until either an effectiveness score exceeds a threshold value, the incremental improvement in effectiveness scores falls below a threshold value, or the number of iterations exceeds a maximum limit. After the iterations terminate, the content creation application may be executed again to create a media content variation result based on the surviving IR variation that is associated with the effectiveness score that exceeded the threshold value, i.e., the most effective content variation.

[0046] In some embodiments, a history of the candidate IR variations is maintained and candidate IR variation resulting from the application of the edits are rejected if the resulting candidate IR variation is present in the history. This prevents the process from degenerating into an infinite loop of edit repetitions.

[0047] In some embodiments, the execution of the content creation application is performed as a batch process to avoid or otherwise reduce redundant processing of candidate IR variations, and the execution of the content evaluation application is performed as a batch process to avoid or otherwise reduce redundant processing of candidate media contents, as previously described.

[0048] Example Platform

[0049] FIG. **8** is a block diagram schematically illustrating a computing platform **800** configured to perform any of the techniques as variously described in this disclosure, configured in accordance with an embodiment of the present disclosure. For example, in some embodiments, the content editing/variation system **100** of FIG. **1**, or any portions thereof as illustrated in FIGS. **2** and **6**, and the methodologies of FIG. **7**, or any portions thereof, are implemented in the computing platform **800**. In some embodiments, the computing platform **800** is a computer system, such as a workstation, desktop computer, server, laptop, handheld computer, tablet computer (e.g., the iPad tablet computer), mobile computing or communication device (e.g., the iPhone mobile communication device, the Android mobile communication device, and the like), or other form of computing device that has sufficient processor power and memory capacity to perform the operations described in this disclosure. In some embodiments, a distributed computational system is provided comprising a plurality of such computing devices.

[0050] The computing platform **800** includes one or more storage devices **890** and/or non-transitory computer-readable media **830** having encoded thereon one or more computer-executable instructions or software for implementing techniques as variously described in this disclosure. In some embodiments, the storage devices **890** include a computer system memory or random-access memory, such as a durable disk storage (e.g., any suitable optical or magnetic durable storage device, including RAM, ROM, Flash, USB drive, or other semiconductor-based storage medium), a hard-drive, CD-ROM, or other computer readable media, for storing data and computer-readable instructions and/or software that implement various embodiments as taught in this disclosure. In some embodiments, the storage device **890** includes other types of memory as well, or combinations thereof. In one embodiment, the storage device **890** is provided on the computing platform **800**. In another embodiment, the storage device **890** is provided separately or remotely from the computing platform **800**. The non-transitory computer-readable media **830** include, but are not limited to, one or more types of hardware memory, non-transitory tangible media (for example, one or more magnetic storage disks, one or more optical disks, one or more USB flash drives), and the like. In some embodiments, the non-transitory computer-readable media **830** included in the computing platform **800** store computer-readable and computer-executable instructions or software for implementing various embodiments. In one embodiment, the computer-readable media **830** are provided on the computing platform **800**. In another embodiment, the computer-readable media **830** are provided separately or remotely from the computing platform **800**.

[0051] The computing platform **800** also includes at least one processor **810** for executing computer-readable and computer-executable instructions or software stored in the storage device **890** and/or non-transitory computer-readable media **830** and other programs for controlling system hardware. In some embodiments, virtualization is employed in the computing platform **800** so that infrastructure and resources in the computing platform **800** are shared dynamically. For example, a virtual machine is provided to handle a process running on multiple processors so that the process appears to be using only one computing resource rather than multiple computing resources. In some embodiments, multiple virtual machines are used with one processor.

[0052] As can be further seen, a bus or interconnect **805** is also provided to allow for communication between the various components listed above and/or other components not shown. Computing platform **800** can be coupled to a network **850** (e.g., a local or wide area network such as the internet), through network interface circuit **840** to allow for communications with other computing devices, platforms, resources, clients, and Internet of Things (IoT) devices.

[0053] In some embodiments, a user interacts with the computing platform **800** through an input/output system **860** that interfaces with devices such as a keyboard and mouse **870** and/or a display element (screen/monitor) **880**. The keyboard and mouse may be configured to provide a user interface to accept user input and guidance, and to otherwise control the content editing/variation system **100**. The display element may be configured, for example, to display the results of editing (e.g., media content with improved effectiveness) using the disclosed techniques. In some embodiments, the computing platform **800** includes other I/O devices (not shown) for receiving input from a user, for example, a pointing device or a touchpad, etc., or any suitable user interface. In some embodiments, the computing platform **800** includes other suitable conventional I/O peripherals. The computing platform **800** can include and/or be operatively coupled to various suitable devices for performing one or more of the aspects as variously described in this disclosure.

[0054] In some embodiments, the computing platform **800** runs an operating system (OS) **820**, such as any of the versions of Microsoft Windows operating systems, the different releases of the Unix and Linux operating systems, any version of the MacOS for Macintosh computers, any embedded operating system, any real-time operating system, any open source operating system, any proprietary operating system, any operating systems for mobile computing devices, or any other operating system capable of running on the computing platform **800** and performing the operations described in this disclosure. In one embodiment, the operating system runs on one or more cloud machine instances.

[0055] As will be appreciated in light of this disclosure, the various modules and components of the system, as shown in FIGS. **1**, **2** and **6**, can be implemented in software, such as a set of instructions (e.g., HTML, XML, C, C++, object-oriented C, JavaScript, Java, BASIC, etc.) encoded on any computer readable medium or computer program product (e.g., hard drive, server, disc, or other suitable non-transient memory or set of memories), that when executed by one or more processors, cause the various methodologies provided in this disclosure to be carried out. It will be appreciated that, in some embodiments, various functions and data transformations performed by the computing system, as described in this disclosure, can be performed by similar processors in different configurations and arrangements, and that the depicted embodiments are not intended to be limiting. Various components of this example embodiment, including the computing platform **800**, can be integrated into, for example, one or more desktop or laptop computers, workstations, tablets, smart phones, game consoles, set-top boxes, or other such computing devices. Other componentry and modules typical of a computing system, such as, for example a co-processor, a processing core, a graphics processing unit, a touch pad, a touch screen, etc., are not shown but will be readily apparent.

[0056] In other embodiments, the functional components/modules are implemented with hardware, such as gate level logic (e.g., FPGA) or a purpose-built semiconductor (e.g., ASIC). Still other embodiments are implemented with a microcontroller having a number of input/output ports for receiving and outputting data, and a number of embedded routines for carrying out the functionality described in this disclosure. In a more general sense, any suitable combination of hardware, software, and firmware can be used, as will be apparent.

Further Example Embodiments

[0057] Numerous example embodiments will be apparent, and features described herein can be combined in any number of configurations.

[0058] Example 1 is a method for improving media content effectiveness, the method comprising: generating, by a processor-based system, an intermediate representation (IR) of a provided media content, wherein the IR specifies one or more editable elements of the media content and maintains a result of cumulative edits to the editable elements; applying, by the processor-based system, edits to one or more of the one or more editable elements of the IR to generate a set of candidate IR variations; executing, by the processor-based system, a content creation application to create a set of candidate media contents based on the set of candidate IR variations; executing, by the processor-based system, a content evaluation application to generate an effectiveness score for each candidate in the set of candidate media contents; pruning, by the processor-based system, the set of candidate IR variations to retain a threshold number of the candidate IR variations as surviving IR variations, the surviving IR variations associated with the highest effectiveness scores; and executing, by the processor-based system, the content creation application to create a media content variation result based on one of the surviving IR variations.

[0059] Example 2 includes the subject matter of Example 1, wherein the one of the surviving IR variations on which the media content variation result is based, is associated with a highest of the effectiveness scores.

[0060] Example 3 includes the subject matter of Examples 1 or 2, wherein executing the content creation application to create a media content variation result based on one of the surviving IR variations comprises: iterating the method for improving media content effectiveness on the surviving IR variations, the iterations terminating if one of the effectiveness scores exceeds a first threshold value, or if an improvement in the effectiveness scores relative to a previous iteration is less than a second threshold value, or if a number of iterations exceeds a third threshold value; and executing the content creation application, after iteration termination, to create the media content variation result based on one of the surviving IR variations.

[0061] Example 4 includes the subject matter of any of Examples 1-3, wherein the media content is one or more of a video stream, a three-dimensional augmented reality scene, an image, a graphic, an audio stream, and a segment of text.

[0062] Example 5 includes the subject matter of any of Examples 1-4, wherein the edits include one or more of adding one or more video frames to the video stream, removing one or more video frames from the video stream, changing color saturation of the image or graphic, adding a segment of audio to the audio stream, removing a segment of audio from the audio stream, and changing one or more words of the segment of text.

[0063] Example 6 includes the subject matter of any of Examples 1-5, further comprising maintaining a history of the candidate IR variations and rejecting a candidate IR variation resulting from the application of the edits, if the resulting candidate IR variation is present in the history.

[0064] Example 7 includes the subject matter of any of Examples 1-6, wherein the content evaluation application generates a confidence value associated with the effectiveness score, and the surviving IR variations are associated with a combination of the highest effectiveness scores and the highest confidence values.

[0065] Example 8 is a system for improving media content effectiveness, the system comprising: one or more processors configured to generate an intermediate representation (IR) of a provided media content, wherein the IR specifies one or more editable elements of the media content and maintains a result of cumulative edits to the editable elements; the one or more processors further configured to apply edits to one or more of the one or more editable elements of the IR to generate a set of candidate IR variations; the one or more processors further configured to execute a content creation application to create a set of candidate media contents based on the set of candidate IR variations; the one or more processors further configured to execute a content evaluation application to generate effectiveness scores for the set of candidate media contents; the one or more processors further configured to prune the set of candidate IR variations to retain a threshold number of the candidate IR variations as surviving IR variations, the surviving IR variations associated with the highest effectiveness scores; and the one or more processors further configured to execute the content creation application to create a media content variation result based on one of the surviving IR variations.

[0066] Example 9 includes the subject matter of Example 8, wherein the one of the surviving IR variations on which the media content variation result is based, is associated with a highest of the effectiveness scores.

[0067] Example 10 includes the subject matter of Examples 8 or 9, the one or more processors further configured to: iterate the process for improving media content effectiveness on the surviving IR variations, the iterations terminating if one of the effectiveness scores exceeds a first threshold value, or if an improvement in the effectiveness scores relative to a previous iteration is less than a second threshold value, or if a number of iterations exceeds a third threshold value; and execute the content creation application, after iteration termination, to create the media content variation result based on one of the surviving IR variations.

[0068] Example 11 includes the subject matter of any of Examples 8-10, wherein the media content is one or more of a video stream, a three-dimensional augmented reality scene, an image, a graphic, an audio stream, and a segment of text.

[0069] Example 12 includes the subject matter of any of Examples 8-11, wherein the edits include one or more of adding one or more video frames to the video stream, removing one or more video frames from the video stream, changing color saturation of the image or graphic, adding a segment of audio to the audio stream, removing a segment of audio from the audio stream, and changing one or more words of the segment of text.

[0070] Example 13 includes the subject matter of any of Examples 8-12, wherein the content evaluation application generates a confidence value associated with the effectiveness score, and the surviving IR variations are associated with a combination of the highest effectiveness scores and the highest confidence values.

[0071] Example 14 is a computer program product including one or more non-transitory machine-readable mediums encoded with instructions that when executed by one or more processors cause a process to be carried out for improving media content effectiveness, the process comprising: generating an intermediate representation (IR) of a provided media content, wherein the IR specifies one or more editable elements of the media content and maintains a result of cumulative edits to the editable elements; applying edits to one or more of the one or more editable elements of the IR to generate a set of candidate IR variations; executing a content creation application to create a set of candidate media contents based on the set of candidate IR variations; executing a content evaluation application to generate an effectiveness score for each candidate in the set of candidate media contents; pruning the set of candidate IR variations to retain a threshold number of the candidate IR variations as surviving IR variations, the surviving IR variations associated with the highest effectiveness scores; and executing the content creation application to create a media content variation result based on one of the surviving IR variations.

[0072] Example 15 includes the subject matter of Example 14, wherein the one of the surviving IR variations on which the media content variation result is based, is associated with a highest of the effectiveness scores.

[0073] Example 16 includes the subject matter of Examples 14 or 15, wherein executing the content creation application to create a media content variation result based on one of the surviving IR variations comprises: iterating the method for improving media content effectiveness on the surviving IR variations, the iterations terminating if one of the effectiveness scores exceeds a first threshold value, or if an improvement in the effectiveness scores relative to a previous iteration is less than a second threshold value, or if a number of iterations exceeds a third threshold value; and executing the content creation application, after iteration termination, to create the media content variation result based on one of the surviving IR variations.

[0074] Example 17 includes the subject matter of any of Examples 14-16, wherein the media content is one or more of a video stream, a three-dimensional augmented reality scene, an image, a graphic, an audio stream, and a segment of text.

[0075] Example 18 includes the subject matter of any of Examples 14-17, wherein the edits include one or more of adding one or more video frames to the video stream, removing one or more video frames from the video stream, changing color saturation of the image or graphic, adding a segment of audio to the audio stream, removing a segment of audio from the audio stream, and changing one or more words of the segment of text.

[0076] Example 19 includes the subject matter of any of Examples 14-18, further comprising maintaining a history of the candidate IR variations and rejecting a candidate IR variation resulting from the application of the edits, if the resulting candidate IR variation is present in the history.

[0077] Example 20 includes the subject matter of any of Examples 14-19, wherein the content evaluation application generates a confidence value associated with the effectiveness score, and the surviving IR variations are associated with a combination of the highest effectiveness scores and the highest confidence values.

[0078] The foregoing description of example embodiments of the disclosure has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure to the precise forms disclosed. Many modifications and variations are possible in light of this disclosure. It is intended that the scope of the disclosure be limited not by this detailed description, but rather by the claims appended hereto.

1. A method for improving media content effectiveness, the method comprising:

generating, by a processor-based system, an initial intermediate representation (IR) of a provided media content, wherein the initial IR specifies one or more editable elements of the provided media content;

applying, by the processor-based system, edits to the initial IR to generate a set of candidate IR variations;

executing, by the processor-based system, a content creation application to create a set of candidate media contents based on the set of candidate IR variations, wherein each candidate IR variation results in creation of a corresponding candidate media content;

executing, by the processor-based system, a content evaluation application to generate, for each candidate media content, (i) an effectiveness score, (ii) a confidence value, and (iii) a weighted effectiveness score based on the effectiveness score and the confidence value; and

pruning, by the processor-based system, the set of candidate IR variations to retain a threshold number of candidate IR variations as surviving IR variations, wherein each of the surviving IR variations is associated with a candidate media content having a weighted effectiveness score that is greater than at least one of the weighted effectiveness scores generated by the content evaluation application.

2. The method of claim **1**, wherein one of the surviving IR variations is associated with a highest of the effectiveness scores generated by the content evaluation application.

3. The method of claim **1**, further comprising:

making a determination that one or more of (i) one of the effectiveness scores generated by the content evaluation application exceeds a first threshold value, or (ii) an improvement in at least one of the effectiveness scores relative to a previous iteration is less than a second threshold value; and

in response to making the determination, executing the content creation application to create a modified media content based on one of the surviving IR variations.

4. The method of claim **1**, wherein the provided media content is one or more of a video stream, a three-dimensional augmented reality scene, an image, a graphic, an audio stream, and a segment of text.

5. The method of claim **4**, wherein the edits include one or more of adding one or more video frames to the video stream, removing one or more video frames from the video stream, changing color saturation of the image or graphic, adding a first segment of audio to the audio stream, removing a second segment of audio from the audio stream, and changing one or more words of the segment of text.

6. The method of claim **1**, further comprising:

maintaining an IR variation history;

making a determination that a particular one of the candidate IR variations generated by applying the edits is included in the IR variation history; and

in response to making the determination, rejecting the particular candidate IR variation before executing the content creation application, wherein no additional candidate media content is created for the particular candidate IR variation.

7. The method of claim **1**, further comprising executing the content creation application to create a modified media content based on one of the surviving IR variations.

8. A system for improving media content effectiveness, the system comprising one or more processors configured to:

generate an initial intermediate representation (IR) of a provided media content, wherein the initial IR specifies one or more editable elements of the provided media content;

apply edits to the initial IR to generate candidate IR variations;

execute a content creation application to create candidate media contents based on the candidate IR variations, wherein each candidate IR variation results in creation of a corresponding candidate media content;

execute a content evaluation application to generate an effectiveness score for each candidate media content;

prune the candidate IR variations to retain a threshold number of candidate IR variations as surviving IR variations;

make a determination that one or more of (i) the effectiveness scores generated by the content evaluation application exceeds a first threshold value, or (ii) an improvement in at least one of the effectiveness scores relative to a previous iteration is less than a second threshold value; and in response to making the determination, execute the content creation application to create a modified media content based on one of the surviving IR variations.

9. The system of claim **8**, wherein one of the surviving IR variations is associated with a highest of the effectiveness scores generated by the content evaluation application.

10. The system of claim **8**, wherein the initial IR maintains a result of cumulative edits to the one or more editable elements.

11. The system of claim **8**, wherein the provided media content is one or more of a video stream, a three-dimensional augmented reality scene, an image, a graphic, an audio stream, and a segment of text.

12. The system of claim **11**, wherein the edits include one or more of adding one or more video frames to the video stream, removing one or more video frames from the video stream, changing color saturation of the image or graphic, adding a first segment of audio to the audio stream, removing a second segment of audio from the audio stream, and changing one or more words of the segment of text.

13. The system of claim **8**, wherein the content evaluation application generates a confidence value associated with at least one of the effectiveness scores.

14. A computer program product including one or more non-transitory machine-readable mediums encoded with instructions that when executed by one or more processors cause a process to be carried out for improving media content effectiveness, the process comprising:

generating an initial intermediate representation (IR) of a provided media content, wherein the initial IR specifies one or more editable elements of the provided media content;

applying edits to the initial IR to generate candidate IR variations;

making a first determination that a particular one of the candidate IR variations generated by applying the edits is included in an IR variation history maintained in the one or more non-transitory machine-readable mediums;

in response to making the first determination, removing the particular candidate IR variation from further consideration;

executing a content creation application to create candidate media contents based on the candidate IR variations, wherein each candidate IR variation results in creation of a corresponding candidate media content, and wherein no additional candidate media content is created based on the particular candidate IR variation that was removed from further consideration;

executing a content evaluation application to generate an effectiveness score for each candidate media content; and

pruning the candidate IR variations to retain a threshold number of candidate IR variations as surviving IR variations.

15. The computer program product of claim **14**, wherein one of the surviving IR variations is associated with a highest of the effectiveness scores generated by the content evaluation application.

16. The computer program product of claim **14**, wherein the process further comprises: making a second determination that one or more of (i) one of the effectiveness scores generated by the content evaluation application exceeds a first threshold value, or (ii) if-an improvement in at least one of the effectiveness scores relative to a previous iteration is less than a second threshold value; and

in response to making the second determination, executing the content creation application to create a modified media content based on one of the surviving IR variations.

17. The computer program product of claim **14**, wherein the initial media content is one or more of a video stream, a three-dimensional augmented reality scene, an image, a graphic, an audio stream, and a segment of text.

18. The computer program product of claim **17**, wherein the edits include one or more of adding one or more video frames to the video stream, removing one or more video frames from the video stream, changing color saturation of the image or graphic, adding a first segment of audio to the audio stream, removing a second segment of audio from the audio stream, and changing one or more words of the segment of text.

19. The computer program product of claim **14**, wherein the process further comprises executing the content creation application to create a modified medial content based on one of the surviving IR variations.

20. The computer program product of claim **14**, wherein the content evaluation application generates a confidence value associated with at least one of the effectiveness scores.

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