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(54) SYSTEMS AND ASSOCIATED METHODS FOR ALIGNING OUTPUTS OF DIFFERENT ARTIFICIAL INTELLIGENCE (AI) MODELS

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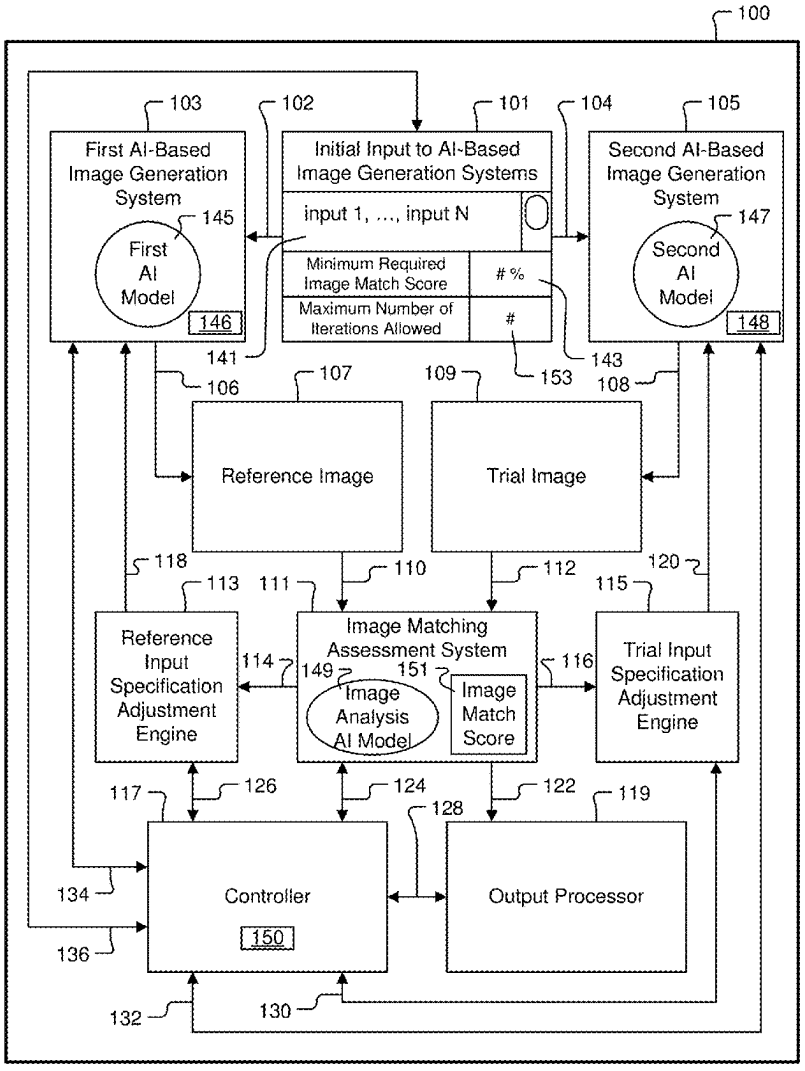
(57) **ABSTRACT**

A first AI-based image generation system generates a reference image based on a reference input specification that is initially set equal to an initial input for AI-based image generation. A second AI-based image generation system generates a trial image based on a trial input specification that is initially set equal to the initial input for AI-based image generation. An image matching assessment system processes the trial image and the reference image through an image analysis AI model to determine an amount of similarity therebetween and generate a corresponding image match score. A trial input specification adjustment engine generates a revised version of the trial input specification for the second AI-based image generation system to generate a new trial image that improves the image match score. In this manner, trial images are iteratively generated until the image match score is equal to or greater than the minimum required image match score.



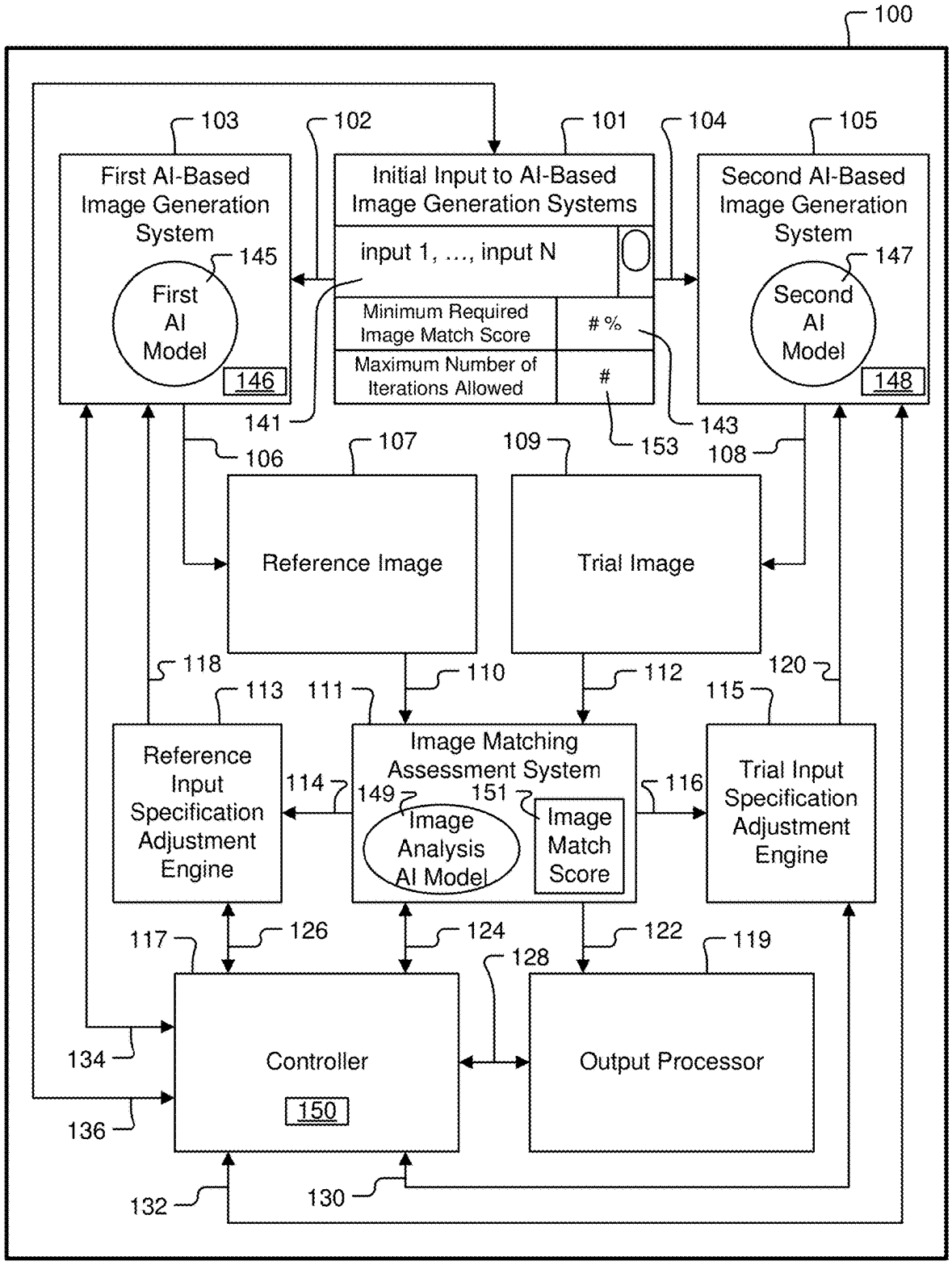

100
103
102
101
104
105
First AI-Based Image Generation System
145
First AI Model
146
Initial Input to AI-Based Image Generation Systems
input 1, ..., input N
Minimum Required Image Match Score
%
Maximum Number of Iterations Allowed
#
Second AI-Based Image Generation System
147
Second AI Model
148
141
143
153
106
107
109
108
Reference Image
Trial Image
118
113
111
110
112
120
115
Reference Input Specification Adjustment Engine
114
Image Matching Assessment System
149
Image Analysis AI Model
151
Image Match Score
116
Trial Input Specification Adjustment Engine
117
126
124
122
119
128
134
Controller
150
Output Processor
136
132
130

Fig. 1

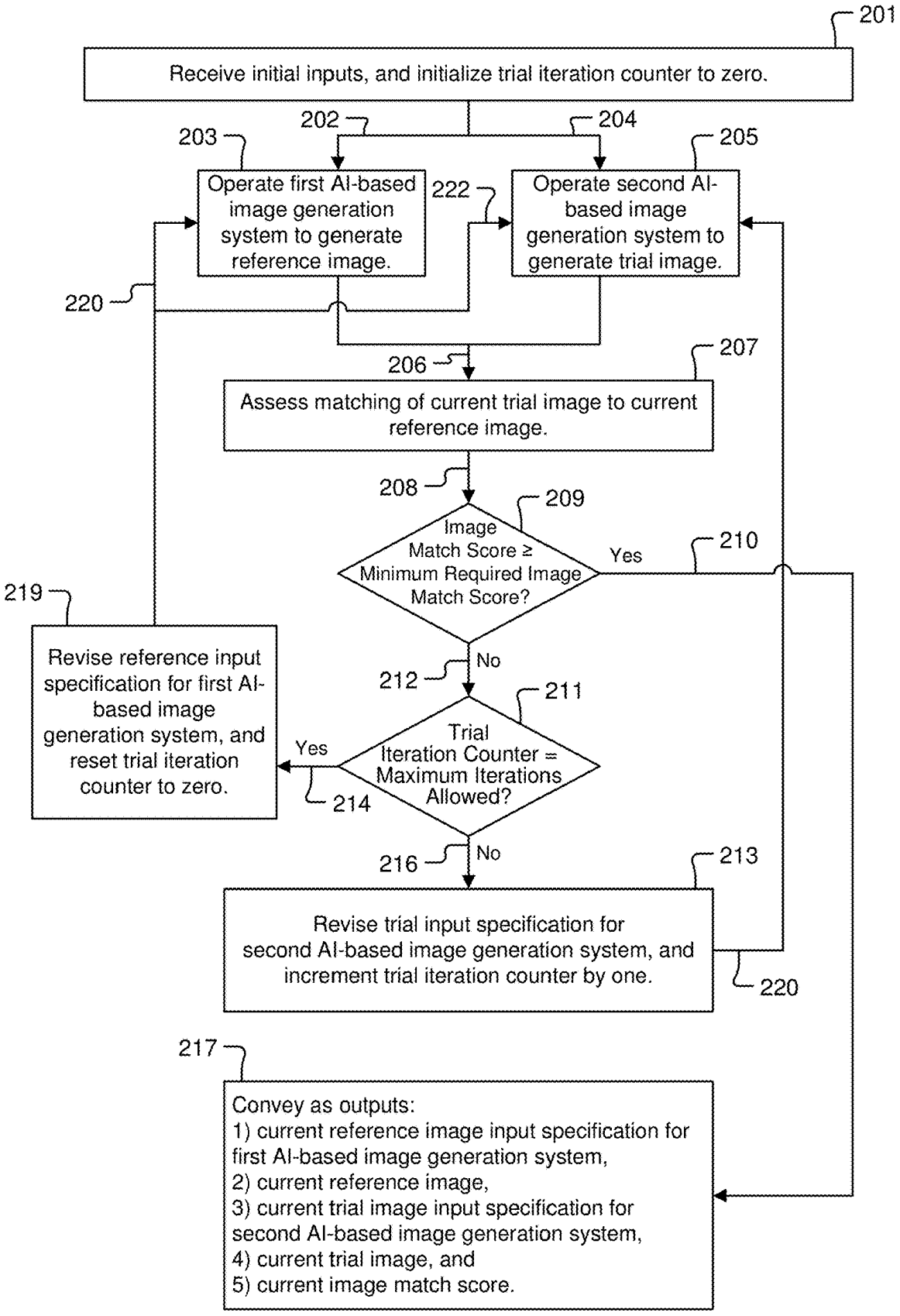

201
Receive initial inputs, and initialize trial iteration counter to zero.
202
204
203
205
Operate first AI-based image generation system to generate reference image.
222
Operate second AI-based image generation system to generate trial image.
220
206
207
Assess matching of current trial image to current reference image.
208
209
Image Match Score ≥ Minimum Required Image Match Score?
Yes
210
219
Revise reference input specification for first AI-based image generation system, and reset trial iteration counter to zero.
No
212
211
Trial Iteration Counter = Maximum Iterations Allowed?
Yes
214
216
No
213
Revise trial input specification for second AI-based image generation system, and increment trial iteration counter by one.
220
217
Convey as outputs:
1) current reference image input specification for first AI-based image generation system,
2) current reference image,
3) current trial image input specification for second AI-based image generation system,
4) current trial image, and
5) current image match score.

Fig. 2

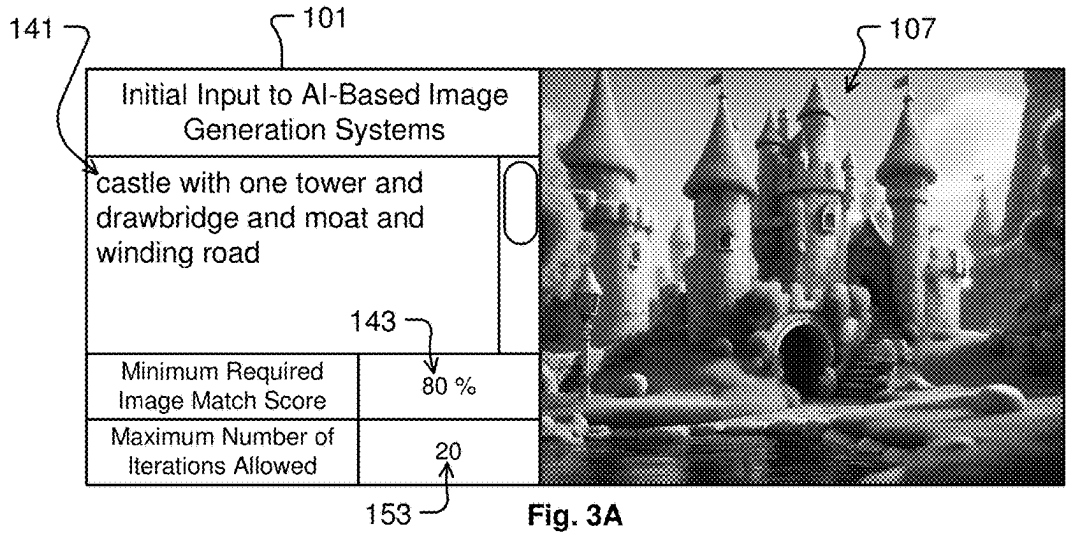

141
101
107
Initial Input to AI-Based Image Generation Systems
castle with one tower and drawbridge and moat and winding road
143
Minimum Required Image Match Score
80 %
Maximum Number of Iterations Allowed
20
153

Fig. 3A

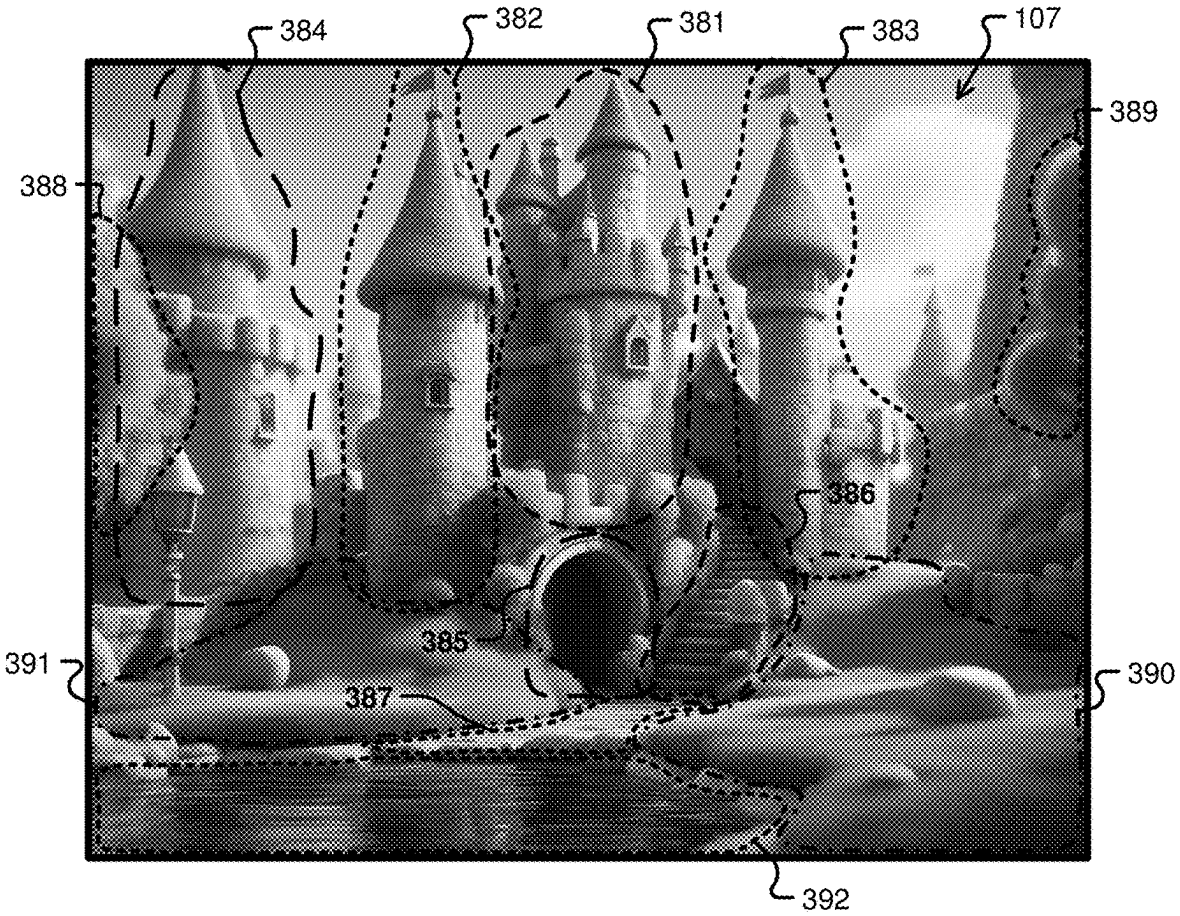

384
382
381
383
107
389
388
386
385
391
387
390
392

Fig. 3B

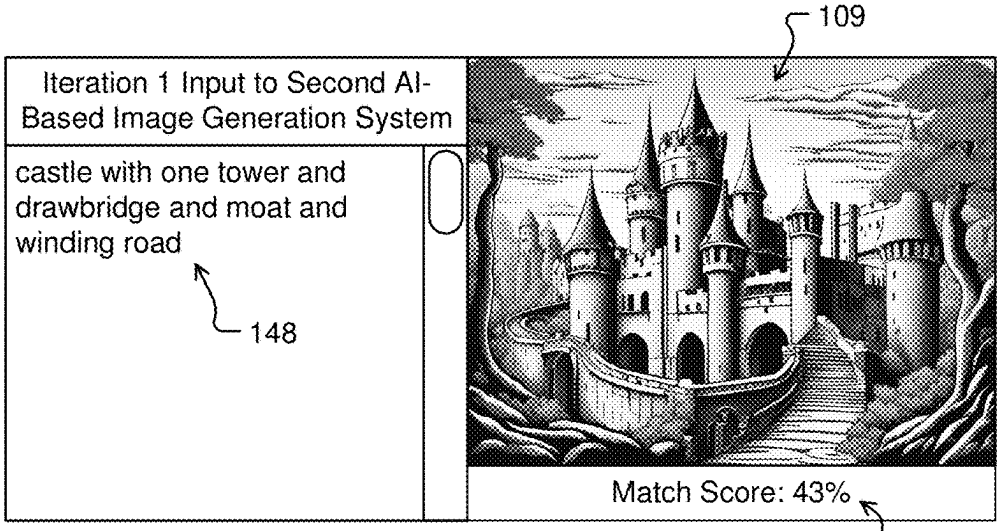


Fig. 3C

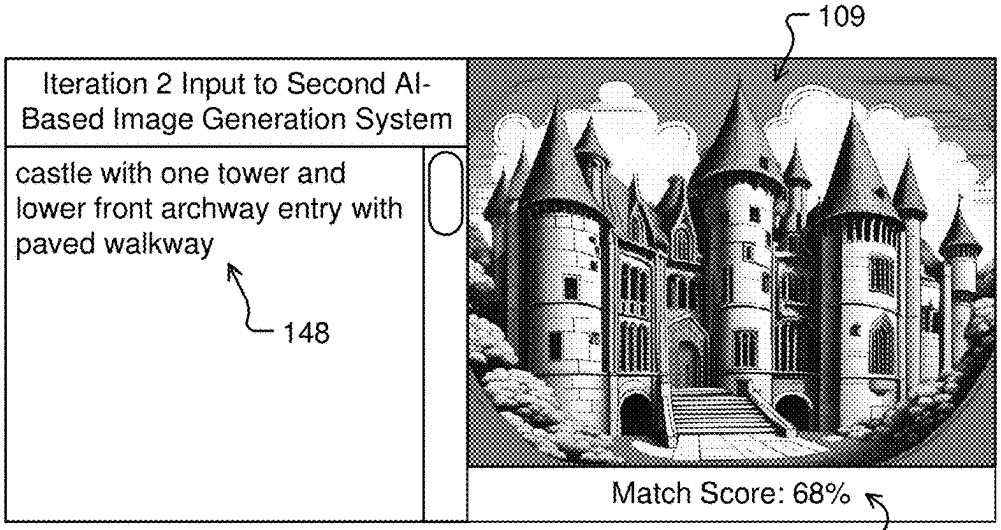


Fig. 3D

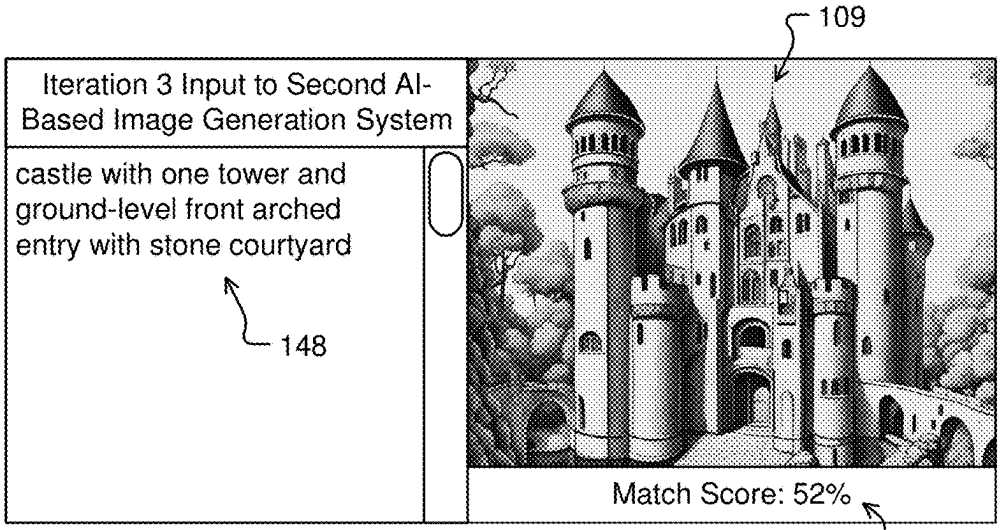


Fig. 3E

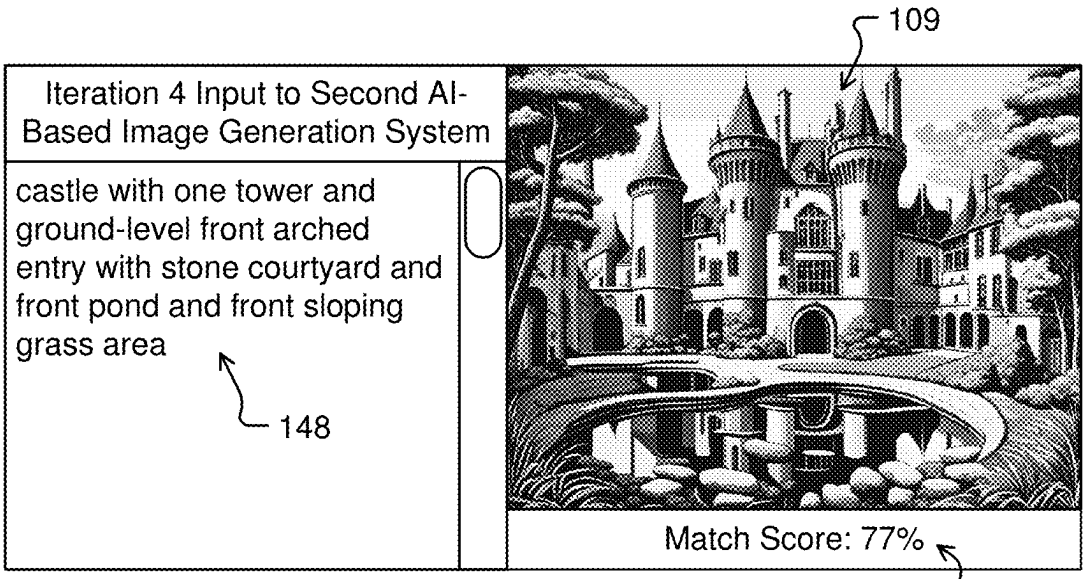

109
Iteration 4 Input to Second AI-Based Image Generation System
castle with one tower and ground-level front arched entry with stone courtyard and front pond and front sloping grass area
148
Match Score: 77%
151

Fig. 3F

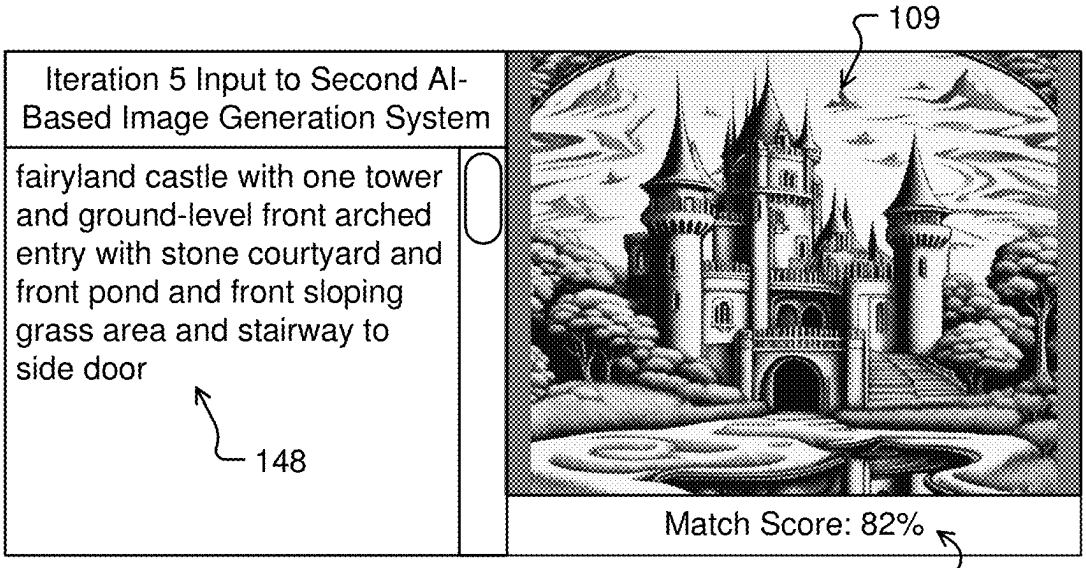

109
Iteration 5 Input to Second AI-Based Image Generation System
fairyland castle with one tower and ground-level front arched entry with stone courtyard and front pond and front sloping grass area and stairway to side door
148
Match Score: 82%
151

Fig. 3G

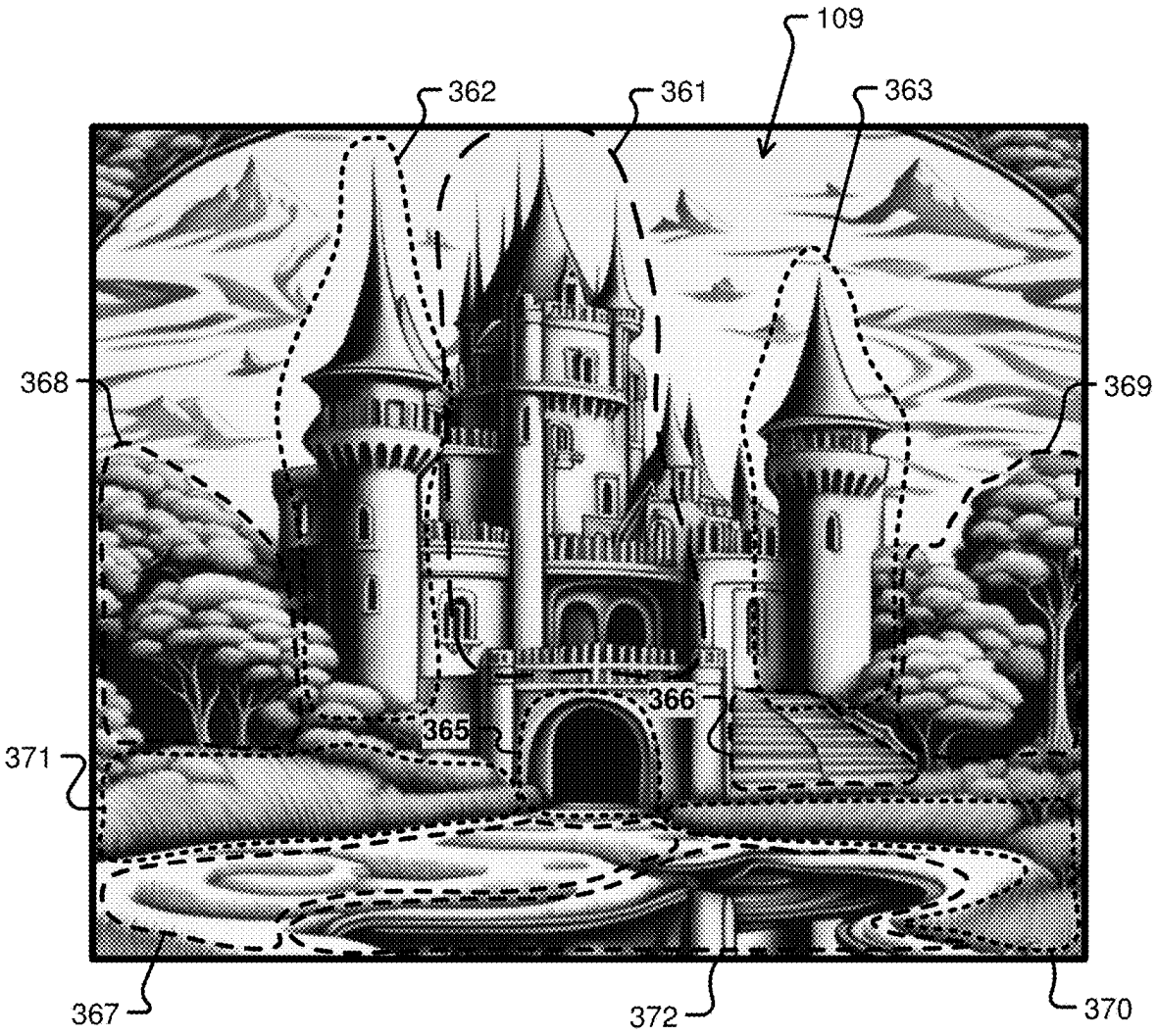


Fig. 3H

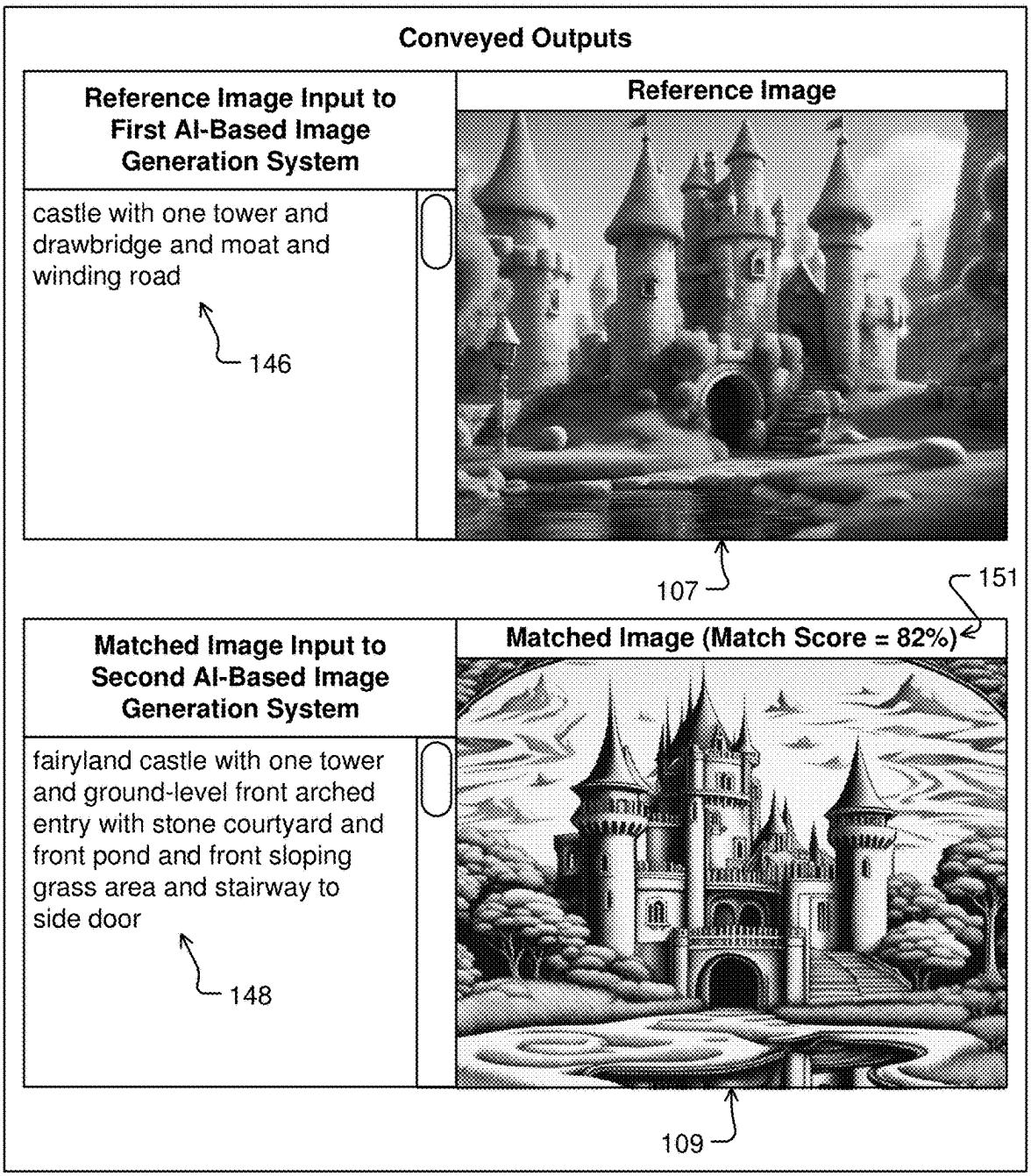

Conveyed Outputs
Reference Image Input to First AI-Based Image Generation System
Reference Image
castle with one tower and drawbridge and moat and winding road
146
107
151
Matched Image Input to Second AI-Based Image Generation System
Matched Image (Match Score = 82%)
fairyland castle with one tower and ground-level front arched entry with stone courtyard and front pond and front sloping grass area and stairway to side door
148
109

Fig. 3I

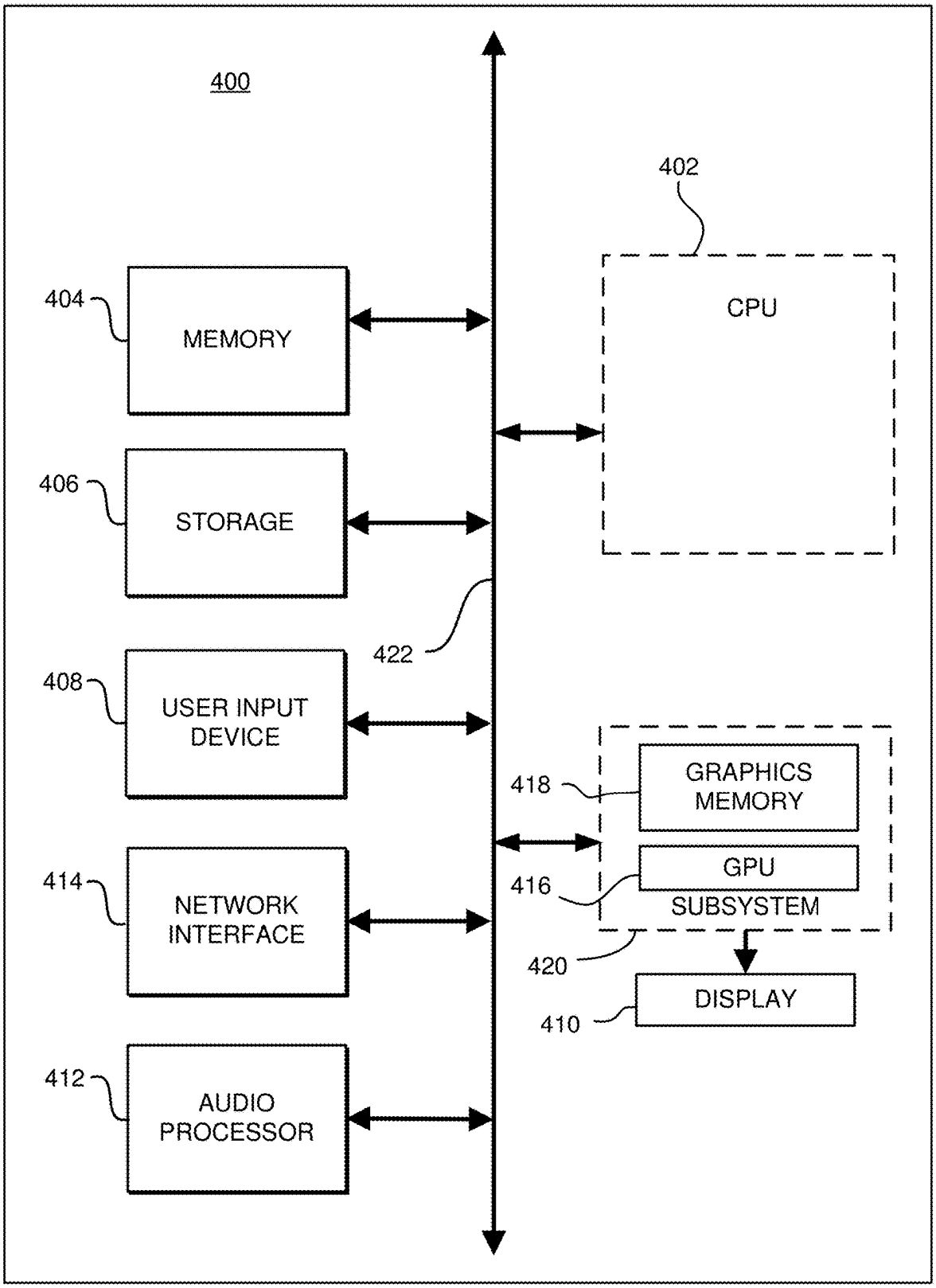

400
402
CPU
404
MEMORY
406
STORAGE
422
408
USER INPUT DEVICE
418
GRAPHICS MEMORY
GPU
416
SUBSYSTEM
414
NETWORK INTERFACE
420
DISPLAY
410
412
AUDIO PROCESSOR

Fig. 4

SYSTEMS AND ASSOCIATED METHODS FOR ALIGNING OUTPUTS OF DIFFERENT ARTIFICIAL INTELLIGENCE (AI) MODELS

BACKGROUND OF THE INVENTION

[0001] The video game industry has seen many changes over the years and has been trying to find ways to enhance the video game play experience for players and increase player engagement with the video games and/or online gaming systems, which ultimately leads to increased revenue for the video game developers and providers and the video game industry in general. Artificial intelligence (AI) is being utilized more in the development of video game content. It is within this context that implementations of the present disclosure arise.

SUMMARY OF THE INVENTION

[0002] In an example embodiment, a system is disclosed for aligning outputs of different AI-based image generation systems. The system includes an input processor configured to receive an initial input for AI-based image generation. The input processor is configured to receive a specification of a minimum required image match score. The system also includes a first AI-based image generation system configured to generate a reference image based on a reference input specification. The reference input specification is initially set equal to the initial input for AI-based image generation. The system also includes a second AI-based image generation system configured to generate a trial image based on a trial input specification. The trial input specification is also initially set equal to the initial input for AI-based image generation. The second AI-based image generation system is different than the first AI-based image generation system. The system also includes an image matching assessment system configured to process the trial image and the reference image through an image analysis AI model to determine an amount of similarity between the trial image and the reference image. The image matching assessment system is configured to generate an image match score based on the determined amount of similarity between the trial image and the reference image. The system also includes a trial input specification adjustment engine configured to generate a revised version of the trial input specification for use in generation of a new version of the trial image by the second AI-based image generation system that provides for an increase of the image match score. The system also includes a controller configured to direct iterative operation of the second AI-based image generation system, the image matching assessment system, and the trial input specification adjustment engine until the image match score is equal to or greater than the minimum required image match score. The system also includes an output processor configured to format and convey as output each of the reference input specification, the reference image, the trial input specification, the trial image, and the image match score when the image match score is equal to or greater than the minimum required image match score.

[0003] In an example embodiment, a method is disclosed for aligning outputs of different AI-based image generation systems. The method includes an operation a) for receiving an initial input for AI-based image generation. The method also includes an operation b) for receiving a specification of a minimum required image match score. The method also includes an operation c) for operating a first AI-based image generation system to generate a reference image based on a reference input specification. The reference input specification is initially set equal to the initial input for AI-based image generation. The method also includes an operation d) for operating a second AI-based image generation system to generate a trial image based on a trial input specification. The trial input specification is also initially set equal to the initial input for AI-based image generation. The second AI-based image generation system is different than the first AI-based image generation system. The method also includes an operation e) for processing the trial image and the reference image through an image analysis AI model to determine an amount of similarity between the trial image and the reference image. The method also includes an operation f) for generating an image match score for the trial image based on the amount of similarity between the trial image and the reference image as determined in operation e). The method also includes an operation g) in which, if the image match score is less than the minimum required image match score, then a trial input specification adjustment engine is operated to generate a revised version of the trial input specification for use in generation of a new version of the trial image by the second AI-based image generation system that provides for an increase of the image match score, followed by sequentially repeating operations d), e), f), and g). Also, in the operation g), if the image match score is greater than or equal to the minimum required image match score, then the method proceeds with an operation h) for formatting and conveying as output each of the reference input specification, the reference image, the trial input specification, the trial image, and the image match score.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. **1** shows a system for aligning graphical image outputs of different AI-based image generation systems, in accordance with some embodiments.

[0005] FIG. **2** shows a flowchart of a method for aligning graphical image outputs of different AI-based image generation systems, in accordance with some embodiments.

[0006] FIG. **3**A shows an example of the initial inputs received through the input processor, in accordance with some embodiments.

[0007] FIG. **3**B shows an example first set of distinguishing features within the example reference image, as identified by the image analysis AI model of the image matching assessment system, in accordance with some embodiments.

[0008] FIG. **3**C shows the trial input specification and corresponding trial image, as generated by the second AI-based image generation system, for a first trial image generation and assessment iteration by the system, in accordance with some embodiments.

[0009] FIG. **3**D shows the trial input specification and corresponding trial image, as generated by the second AI-based image generation system, for a second trial image generation and assessment iteration by the system, in accordance with some embodiments.

[0010] FIG. **3**E shows the trial input specification and corresponding trial image, as generated by the second AI-based image generation system, for a third trial image generation and assessment iteration by the system, in accordance with some embodiments.

[0011] FIG. **3**F shows the trial input specification and corresponding trial image, as generated by the second AI-

based image generation system, for a fourth trial image generation and assessment iteration by the system, in accordance with some embodiments.

[0012] FIG. **3**G shows the trial input specification and corresponding trial image, as generated by the second AI-based image generation system, for a fifth trial image generation and assessment iteration by the system, in accordance with some embodiments.

[0013] FIG. **3**H shows an example second set of distinguishing features within the example trial image of the fifth iteration, as identified by the image analysis AI model of the image matching assessment system, in accordance with some embodiments.

[0014] FIG. **3**I shows the outputs as formatted and conveyed by the output processor for the example operation of the system as shown in FIGS. **3**A-**3**H, in accordance with some embodiments.

[0015] FIG. **4** shows various components of an example server device within a cloud-based computing system that can be used to perform aspects of the system and method for aligning outputs of different artificial AI-based image generation systems, in accordance with some embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0016] In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. It will be apparent, however, to one skilled in the art that embodiments of the present disclosure may be practiced without some or all of these specific details. In other instances, well known process operations have not been described in detail in order not to unnecessarily obscure the present disclosure.

[0017] Many modern computer applications, such as video games, virtual reality applications, augmented reality applications, virtual world applications, etc., include many images of many different virtual objects (or virtual assets). For ease of description, the term "computer application" as used herein refers to any type of computer application in which images of virtual objects (or virtual assets) are displayed. For ease of description, the term "designer" as used herein refers to a real-world person that engages in the activity of creating images for virtual objects for use in computer applications. Also, for ease of description, the term "user" as used herein refers to a real-world person that utilizes the systems and methods disclosed herein for generating images of virtual objects. In some embodiments, a user is a designer of a images for use in computer applications.

[0018] Images of virtual objects and/or scenes are created by designers to fit the context of the computer application in which they will be displayed. The virtual objects can be essentially any noun, e.g., any person, place, or thing. The virtual scenes can include any number, shape, size, orientation, color, texture, and arrangement of virtual objects. It should be appreciated that there is an essentially limitless number of ways in which any given virtual object and virtual scene can be imagined, designed, specified, and imaged by a designer. For example, consider a particular context of a particular computer application that calls for display of a tree as a virtual object in a park. In designing the virtual object for the tree, the designer is tasked with specifying many attributes of the tree, such as the height, the trunk shape, the trunk size, the canopy shape, the canopy size, the shapes of branches, the type of foliage, the type of bark, the color(s) of the bark, the color(s) of the branches, the color(s) of the foliage, the density of the foliage, the presence of fruit/berries/flowers/nuts/cones, the types of fruit/berries/flowers/nuts/cones, the shapes of the fruit/berries/flowers/nuts/cones, the sizes of the fruit/berries/flowers/nuts/cones, the colors of the fruit/berries/flowers/nuts/cones, the distribution of the fruit/berries/flowers/nuts/cones within the foliage, among other attributes. Moreover, the various options for the park scenery in which the tree exists is essentially limitless. It should be appreciated that for many virtual objects/scenes, there are many attributes that define the virtual object/scene and there are many different possible specifications for each of the many attributes, which can often result in enormous number of possible variations of the virtual object/scene. The graphical image designer is challenged to create an image of a particular version or instance of a particular virtual object and/or virtual scene that coheres with a particular context of the computer application and that satisfies one or more visual objectives. In various embodiments, the visual objectives can include providing visual variety, promoting visual interest, attracting attention, conveying meaning, provoking emotion, inviting contemplation, stimulating user interaction with the computer application, among many other visual objectives. Therefore, it is of interest to develop automatic and/or semi-automatic ways to assist the designer with the design of virtual objects and virtual scenes for use in computer applications. To this end, various systems and methods are disclosed herein by which a user, e.g., graphical image designer, can leverage artificial intelligence (AI) capabilities in assisting with generation of graphical images for use in computer applications.

[0019] In some situations, a designer is tasked with creating multiple different versions of a same virtual object and/or a same virtual scene. For example, a given context of a video game may require that the same virtual object/scene be presented in multiple different ways. For example, consider a video game that can be played in either realistic graphics mode, flat graphics mode, children's graphics mode, line-art graphics mode, cartoon graphics mode, caricature graphics mode, minimalist graphics mode, comics graphics mode, retro graphics mode, among essentially any other type of graphics mode. The video game graphics designer has to create the graphics for the various virtual objects/scenes and other graphical image content of the video game for each graphics mode of the video game that is to be offered. In some embodiments, the various virtual objects/scenes, content, and functionality of the video game remains essentially the same for the different graphics modes of the video game. Therefore, a significant advancement in graphics design efficiency and time-to-market is possible if the designer is equipped with AI-based tools to provide for automatic or semi-automatic creation of various virtual objects/scenes and other graphical image content of the video game for a given graphics mode of the video game based on corresponding objects/scenes and other graphical image content already generated for another graphics mode of the video game. More specifically, the designer can originate various virtual objects/scenes and other graphical image content of the video game for a first graphics mode of the video game, and then use the AI-based systems and methods disclosed herein to automatically and/or semi-automatically create the same various virtual objects/scenes and other graphical image content of the video game for a

second graphics mode of the video game, with the original various virtual objects/scenes and other graphical image content of the video game for the first graphics mode of the video game being used as reference input by the AI-based systems and methods disclosed herein.

[0020] Various embodiments are disclosed herein for systems and methods for aligning outputs of different AI-based image generation systems. It is considered that multiple different AI-based image generation systems are provided for automatically generating a graphical image based on a set of linguistic input, e.g., a textual description of the image to be generated. In some embodiments, each of the multiple different AI-based image generations systems is configured and trained to generate a graphical image of a particular graphical image genre. Also, in these embodiments, each of the multiple different AI-based image generation systems is configured and trained to generate a different genre of graphical image relative to others of the multiple different AI-based image generation systems. In various embodiments, the different genres of graphical images, e.g., virtual objects and/or virtual scenes, generated by the multiple different AI-based image generation systems include one or more of abstract, action, alien, apocalyptic, architectural, ancient, anime, antique, art-deco, art-nouveau, avatar, baroque, bauhaus, caricature, cartoon, chibi, children's book, comics, contemporary, cubism, cyberpunk, decoupage, dreamscape, dystopian, elven-world, emoji, ethnic, fairytale, fantasy, flat, fresco, futuristic, gothic, grotesque, haunted, hologram, impressionist, line-art, logo, manga, mechanica, minimalist, mystical, mythological, neo-noir, oceanic, photorealistic, pixel-art, pixel-world, pop-art, post-impressionist, psychedelic, realistic, renaissance, retro, romantic-art, rural, satire, science fiction, space, stained glass, steampunk, street-art, superhero, supernatural, surreal, three-dimensional character, three-dimensional object, tribal, urban, vintage, watercolor, western, among many other genres.

[0021] In some embodiments, a first AI-based image generation system is engaged to generate a reference image based on an initial input specification that provides a linguistic, e.g., textual, description of the image to be generated. Then, a second AI-based image generation system is engaged to automatically generate another image that substantially matches, e.g., looks like or aligns with, the reference image. Operating the second AI-based image generation system to achieve the other image that substantially matches reference image is generally an iterative process that requires generation of many trial images and accompanying assessment of how well each trial image matches the reference image until a sufficient match is deemed to have been achieved. This iterative process includes adjustment and refinement of the linguistic description of the image to be generated in order to provide different input specifications to the second AI-based image generation system for generating the various trial images. The systems and methods disclosed herein provide for automatic control and direction of the above-mentioned iterative process to achieve an image generated by the second AI-based image generation system that substantially matches the reference image generated by the first AI-based image generation system. The systems and methods disclosed herein implement various AI models to automatically compare the various trial images and the reference image during the iterative process. The systems and methods disclosed herein also implement various AI models to automatically generate the revised/updated linguistic input to the second AI-based image generation system for each iteration of the iterative process. Also, in some embodiments, if the generated trial images do not converge to substantially match the reference image within a specified maximum number of iterations, the system and methods disclosed herein implement various AI models to automatically generate a revised/updated linguistic input to the first AI-based image generation system to generate an updated/revised reference image that resolves problematic features/characteristics of the previous version of the reference image that were not being successfully matched by the trial images. In various embodiments, the first AI-based image generation system is configured and trained to generate the reference image in accordance with a first genre, and the second AI-based image generation system is configured and trained to generate the trial image in accordance with a second genre. In some embodiments, the first and second genres are substantially the same. In some embodiments, the first and second genres are different.

[0022] FIG. **1** shows a system **100** for aligning graphical image outputs of different AI-based image generation systems, in accordance with some embodiments. The system **100** includes an input processor **101** configured to receive an initial input for AI-based image generation **141**. In some embodiments, the initial input for AI-based image generation **141** is a linguistic description of a graphical image. In some embodiments, the initial input for AI-based image generation **141** is specified as textual input. In some embodiments, the initial input for AI-based image generation **141** is specified through verbal/audio input that is transcribed into textual input. In various embodiments, the graphical image is essentially any graphical image that is displayable on a display screen of a computer system. In various embodiments, the graphical image is essentially any type of graphical image that displayable by a computer application, such as a video game. The input processor **101** is also configured to receive a specification of a minimum required image match score **143**. In some embodiments, the minimum required image match score **143** represents the percentage of a reference image **107** that is substantially matched by a trial image **109**. In some embodiments, the minimum required image match score **143** is computed as a percentage of AI-classified and AI-labeled distinguishing features within the reference image **107** that have substantially matching AI-classified and AI-labeled distinguishing features within the trial image **109**.

[0023] The system **100** includes a first AI-based image generation system **103** configured to generate and output the reference image **107**, as indicated by arrow **106**, based on a reference input specification **146**. In some embodiments, the reference input specification **146** is a linguistic description of a graphical image, e.g., a textual description of the image. The reference input specification **146** is initially set equal to the initial input for AI-based image generation **141** as received through the input processor **101**. More specifically, the first AI-based image generation system **103** receives the initial input for AI-based image generation **141** from the input processor **101**, as indicated by arrow **102**, and initializes the reference input specification **146** to the initial input for AI-based image generation **141**. The first AI-based image generation system **103** includes one or more AI model(s) **145** configured and trained to generate a first genre of graphical image. For ease of description, the one or more AI

model(s) **145** is referred to hereafter as a first AI model **145**. It should also be understood that the first AI-based image generation system **103** is implemented as a combination of rules-based algorithms and one or more AI models, including at least the first AI model **145**.

[0024] The system **100** also includes a second AI-based image generation system **105** configured to generate and output the trial image **109**, as indicated by arrow **108**, based on a trial input specification **148**. In some embodiments, the trial input specification **148** is a linguistic description of a graphical image, e.g., a textual description of the image. The trial input specification **148** is initially set equal to the initial input for AI-based image generation **141** as received through the input processor **101**. More specifically, the second AI-based image generation system **105** receives the initial input for AI-based image generation **141** from the input processor **101**, as indicated by arrow **104**, and initializes the trial input specification **148** to the initial input for AI-based image generation **141**. The second AI-based image generation system **105** is different than the first AI-based image generation system **103**. The second AI-based image generation system **105** includes one or more AI model(s) **147** configured and trained to generate a second genre of graphical image.

[0025] In some embodiments, the second genre of graphical image generated by the second AI-based image generation system **105** is different than the first genre of graphical image generated by the first AI-based image generation system **103**. However, in some embodiments, the second genre of graphical image generated by the second AI-based image generation system **105** is substantially similar to the first genre of graphical image generated by the first AI-based image generation system **103**. For ease of description, the one or more AI model(s) **147** is referred to hereafter as a second AI model **147**. It should also be understood that the second AI-based image generation system **105** is implemented as a combination of rules-based algorithms and one or more AI models, including at least the second AI model **147**.

[0026] The system **100** also includes an image matching assessment system **111** configured to receive as input a current version of the reference image **107**, as indicated by arrow **110**. The image matching assessment system **111** is also configured to receive as input a current version of the trial image **109**, as indicated by arrow **112**. The image matching assessment system **111** is configured to process the trial image **109** and the reference image **107** through an image analysis AI model **149** to determine an amount of similarity between the trial image **109** and the reference image **107**. In some embodiments, the image matching assessment system **111** is configured to automatically identify a given distinguishing feature within a given image (reference image **107** and/or trial image **109**) by determining an outline and content of the given distinguishing feature within the given image. In some embodiments, the image analysis AI model **149** is configured to implement a pixel-level analysis of the given image to automatically identify pixels associated with the outline and content of the given distinguishing feature within the given image.

[0027] In some embodiments, the image analysis AI model **149** is configured to automatically extract and characterize attributes of distinguishing features within each of the reference image **107** and the trial image **109**. In some embodiments, the image analysis AI model **149** is configured to analyze the current version of the reference image **107** to identify and characterize a first set of one or more distinguishing features within the current version of the reference image **107**. Also, in these embodiments, the image analysis AI model **149** is configured to analyze the current version of the trial image **109** to identify and characterize a second set of one or more distinguishing features within the current version of the trial image **109**. Also, in these embodiments, the image analysis AI model **149** is configured to classify and label identified candidate features within the current version of the reference image **107**. Also, in these embodiments, the image matching assessment system **111** is configured to filter the classified and labeled candidate features within the current version of the reference image **107** in accordance with a number of filter parameters to determine the first set of one or more distinguishing features within the current version of the reference image **107**. Also, in these embodiments, the image analysis AI model **149** is configured to classify and label identified candidate features within the current version of the trial image **109**. Also, in these embodiments, the image matching assessment system **111** is configured to filter the classified and labeled candidate features within the current version of the trial image **109** in accordance with the number of filter parameters to determine the second set of one or more distinguishing features within the current version of the trial image **109**. In some of these embodiments, the number of filter parameters includes a minimum size for a given distinguishing feature within a given image (reference image **107** and/or trial image **109**). For example, in some embodiments, the minimum size for a given distinguishing feature within a given image is specified as a percentage of a total size of the given image occupied by the given distinguishing feature. In another example, in some embodiments, the minimum size for a given distinguishing feature within a given image is specified as a total number of pixels used to display the given distinguishing feature within the given image.

[0028] The image matching assessment system **111** is also configured to generate a current image match score **151** based on the determined amount of similarity between the current version of the trial image **109** and the current version of the reference image **107**. In some embodiments, the image matching assessment system **111** is configured to generate the current image match score **151** by evaluating a number of comparison parameters for correlated distinguishing features in the current version of the reference image **107** and the current version of the trial image **109**. In some embodiments, the number of comparison parameters includes one or more of a feature size, a feature shape, a feature contextual position, a feature spatial orientation, a feature texture, a feature color, a feature-to-feature relationship, a pixel intensity gradient, a pixel color, and a pixel-level color gradient, among other comparison parameters.

[0029] The system **100** also includes a trial input specification adjustment engine **115** configured to generate a revised version of the trial input specification **148** for use in generation of a new version of the trial image **109** by the second AI-based image generation system **105** that provides for an increase of the current image match score **151**. The output of the image analysis AI model **149** and the current image match score **151** are provided as inputs to the trial input specification adjustment engine **115**, as indicated by arrow **116**. When the current image match score **151** is less than the minimum required image match score **143** as

specified through the input processor **101**, the trial input specification adjustment engine **115** is engaged to determine a revised version of the trial input specification **148** that will drive the second AI-based image generation system **105** to generate a new trial image **109** that better matches (e.g., better aligns with) the current version of the reference image **107**. The revised version of the trial input specification **148** is conveyed from the trial input specification adjustment engine **115** to the second AI-based image generation system **105**, as indicated by arrow **120**. The output of the image analysis AI model **149** of the image matching assessment system **111** provides image mismatch information to the trial input specification adjustment engine **115** indicating how the current version of the trial image **109** is not matching/aligning with the current version of the reference image **107**. The trial input specification adjustment engine **115** uses the image mismatch information to automatically generate a revision of the trial input specification **148** that will drive the second AI-based image generation system **105** to generate a new version of the trial image **109** that yields a higher current image match score **151** when processed through the image matching assessment system **111**. For example, in some embodiments, the trial input specification adjustment engine **115** is configured to generate a revision of the trial input specification **148** for the second AI-based image generation system **105** that will reduce or eliminate one or more mismatches between a portion of (or given feature displayed within) the current version of the reference image **107** and a corresponding portion of (or given feature displayed within) the current version of the trial image **109**.

[0030] The system also includes a controller **117** that is configured to direct iterative operation of the second AI-based image generation system **105**, the image matching assessment system **111**, and the trial input specification adjustment engine **115** until the current image match score **151** is equal to or greater than the minimum required image match score **143** as specified through the input processor **101**. The controller **117** is in bi-directional data communication with the input processor **101**, as indicated by arrow **136**. The controller **117** is also in bi-directional data communication with the first AI-based image generation system **103**, as indicated by arrow **134**. The controller **117** is also in bi-directional data communication with the second AI-based image generation system **105**, as indicated by arrow **132**. The controller **117** is also in bi-directional data communication with the image matching assessment system **111**, as indicated by arrow **124**. The controller **117** is also in bi-directional data communication with the trial input specification adjustment engine **115**, as indicated by arrow **130**.

[0031] The controller **117** is configured to direct when the initial input for AI-based image generation **141** is conveyed from the input processor **101** to the first AI-based image generation system **103** for generation of the initial version of the reference image **107**. The controller **117** is also configured to direct when the initial input for AI-based image generation **141** is conveyed from the input processor **101** to the second AI-based image generation system **105** for generation of the initial version of the trial image **109**. The controller **117** is also configured to direct when current version of the reference image **107** and the current version of the trial image **109** are conveyed to the image matching assessment system **111** for processing by the image analysis AI model **149** to generate the current image match score **151**. The controller **117** is also configured to direct when the output of the image analysis AI model **149** and the current image match score **151** are conveyed to the trial input specification adjustment engine **115**. The controller **117** is also configured to direct when the trial input specification adjustment engine **115** is engaged to generate the revision of the trial input specification **148** for the second AI-based image generation system **105**. The controller **117** is also configured to direct when the revision of the trial input specification **148** is conveyed from the trial input specification adjustment engine **115** to the second AI-based image generation system **105**. The controller **117** is also configured to direct when the second AI-based image generation system **105** is engaged to generate a new version of the trial image **109** based on the revision of the trial input specification **148** as received from the trial input specification adjustment engine **115**. In this manner, the controller **117** is configured to control operation of the system **100** in an iterative manner to obtain a current version of the trial image **109** that sufficiently matches (aligns with) a current version of the reference image **107**, such that the current image match score **151** for the current version of the trial image **109** relative to the current version of the reference image **107** is greater than or equal to the minimum required image match score **143** as specified through the input processor **101**.

[0032] The system **100** also includes an output processor **119** that is configured to format and convey as output (to the user of the system **100**) each of the current version of the reference input specification **146**, the current version of the reference image **107**, the current version of the trial input specification **148**, the current version of the trial image **109**, and the current image match score **151**, when the current image match score **151** is determined to be equal to or greater than the minimum required image match score **143**. The controller **117** is in bi-directional data communication with the output processor **119**, as indicated by arrow **128**. The controller **117** directs when the output processor **119** is engaged to format and convey the outputs as indicated above. In some embodiments, the output processor **119** receives the current version of the reference input specification **146**, the current version of the reference image **107**, the current version of the trial input specification **148**, the current version of the trial image **109**, and the current image match score **151** from the image matching assessment system **111**, as indicated by arrow **122**. In other embodiments, the output processor **119** receives the current version of the reference input specification **146**, the current version of the reference image **107**, the current version of the trial input specification **148**, the current version of the trial image **109**, and the current image match score **151** from the controller **117**, as indicated by arrow **128**.

[0033] In some embodiments, sufficient matching/alignment convergence of the trial image **109** to the reference image **107** is not attainable within a specified maximum allowed number of iterations **153** of trial image **109** generation. In some embodiments, the system **100** provides for specification of the maximum allowed number of iterations allowed **153** through the input processor **101** by the user of the system **100**. In some embodiments, the current reference image **107** is designed in such a way that the system **100** is unable to generate a current trial image **109** with an accompanying current image match score **151** that is greater than or equal to the minimum required image match score **143** in the specified maximum allowed number of iterations **153** of trial image **109** generation. In some embodiments, the

system **100** implements a reference input specification adjustment engine **113** to manage the lack of sufficient matching/alignment convergence of the trial image **109** to the reference image **107** within the specified maximum allowed number of iterations **153** of trial image **109** generation. The reference input specification adjustment engine **113** is configured to generate a revised version of the reference input specification **146** for use in generation of a new version of the reference image **107** by the first AI-based image generation system **103**. In some embodiments, the reference input specification adjustment engine **113** is configured to receive as inputs the output of the image analysis AI model **149** and the current image match score **151** from the image matching assessment system **111**, as indicated by arrow **114**. Using the output of the image analysis AI model **149**, the reference input specification adjustment engine **113** is informed of which one or more portion(s) and/or distinguishing feature(s) of the current version of the reference image **107** are problematic in that they are not being sufficiently matched by the current version of the trial image **109**. The reference input specification adjustment engine **113** is configured to generate a revised version of the reference input specification **146** that seeks to mitigate or eliminate the problematic portion(s) and/or distinguishing feature(s) of the reference image **107**, with the objective of enabling matching/alignment convergence of the trial image **109** to the reference image **107** within the specified maximum allowed number of iterations **153** of trial image **109** generation.

[0034] The revised version of the reference input specification **146** is conveyed from the reference input specification adjustment engine **113** to the first AI-based image generation system **103**, as indicated by arrow **118**. The first AI-based image generation system **103** uses the revised version of the reference input specification **146** to generate a new current version of the reference image **107**. The system **100** reinitializes the trial image **109** by directing the second AI-based image generation system **105** to use the revised version of the reference input specification **146** as the trial input specification **148** to generate a new current version of the trial image **109**. Then, the system **100** proceeds with the iterative process of trial image **109** generation, matching assessment, and corresponding image match score **151** computation based on the new current version of the reference image **107**.

[0035] The controller **117** is in bi-directional data communication with the reference input specification adjustment engine **113**, as indicated by arrow **126**. In some embodiments, the controller **117** is configured to increment a trial iteration counter **150** for each time the second AI-based image generation system **105** generates the new current version of the trial image **109** based on the revised version of the trial input specification **148** as generated by the trial input specification adjustment engine **115**. Also, in these embodiments, the controller **117** is further configured to direct the reference input specification adjustment engine **113** to generate the revised version of the reference input specification **146** and to direct the first AI-based image generation system **103** to generate the new current version of the reference image **107** when the trial iteration counter **150** exceeds the specified maximum allowed number of iterations **153**. Also, in these embodiments, the controller **117** is further configured to direct the second AI-based image generation system **105** to use the revised version of the reference input specification **146** as the trial input specification **148** to generate a new current version of the trial image **109** when the revised version of the reference input specification **146** is used by the first AI-based image generation system **103** to generate the new current version of the reference image **107**.

[0036] The controller **117** is configured to initialize the trial iteration counter **150** to zero each time the trial input specification **148** that is provided to the second AI-based image generation system **105** matches the reference input specification **146** that is provided to the first AI-based image generation system **103**. Therefore, the trial iteration counter **150** is initialized to zero when the initial input for AI-based image generation **141** is used as both the reference input specification **146** for the first AI-based image generation system **103** and as the trial input specification **148** for the second AI-based image generation system **105**. Also, the trial iteration counter **150** is initialized to zero when the revised version of the reference input specification **146** is used for both the reference input specification **146** to the first AI-based image generation system **103** and the trial input specification **148** to the second AI-based image generation system **105**.

[0037] It should be understood that the system **100** is operable by a user, e.g., designer, to automatically and/or semi-automatically create multiple versions, e.g., genres, of a given graphical image. In some embodiments, the multiple versions of the given graphical image, as generated by the system **100**, are associated with a computer application, such as a video game. In some embodiments, the multiple versions of the given graphical image correspond to graphics scenes that are displayed by a computer application. In some embodiments, the multiple versions of the given graphical image correspond to virtual objects that are displayed by a computer application.

[0038] FIG. **2** shows a flowchart of a method for aligning graphical image outputs of different AI-based image generation systems, in accordance with some embodiments. The method includes an operation **201** for receiving initial input that includes the initial input for AI-based image generation **141** and the specification of the minimum required image match score **143**. The operation **201** also includes initializing the trial iteration counter **150** to zero. From the operation **201**, the method proceeds with an operation **203**, as indicated by arrow **202**, for operating the first AI-based image generation system **103** to generate the current version of the reference image **107** based on the reference input specification **146**, where the reference input specification **146** is initially set equal to the initial input for AI-based image generation **141**. Also, from the operation **201**, the method proceeds with an operation **205**, as indicated by arrow **204**, for operating the second AI-based image generation system **105** to generate the current version of the trial image **109** based on the trial input specification **148**, where the trial input specification **148** is initially set equal to the initial input for AI-based image generation **141**. It should be understood that the second AI-based image generation system **105** is different than the first AI-based image generation system **103**. In some embodiments, the operation **203** includes executing one or more image generation AI model (s) to generate a first genre of graphical image, and the operation **205** includes executing one or more image generation AI model(s) to generate a second genre of graphical image. In some embodiments, the second genre is different

from the first genre. In some embodiments, the second genre is substantially the same as the first genre. In some embodiments, each of the initial input for AI-based image generation **141**, the reference input specification **146**, and the trial input specification **148** is a respective linguistic description of an image, e.g., a textual or verbal/audio description of the image.

[0039] From the operations **203** and **205**, the method proceeds with an operation **207**, as indicated by arrow **206**, for processing the current version of the trial image **109** and the current version of the reference image **107** through the image analysis AI model **149** of the image matching assessment system **111** to determine an amount of similarity between the current version of the trial image **109** and the current version of the reference image **107**. The operation **207** also includes generating the current image match score **151** for the current version of the trial image **109** based on the determined amount of similarity between the current version of the trial image **109** and the current version of the reference image **107**. In some embodiments, generating the current image match score **151** in the operation **207** includes evaluating a number of comparison parameters for correlated distinguishing features in the reference image **107** and the trial image **109**. In some embodiments, the number of comparison parameters include one or more of a feature size, a feature shape, a feature contextual position, a feature spatial orientation, a feature texture, a feature color, a feature-to-feature relationship, a pixel intensity gradient, a pixel color, and a pixel-level color gradient, among other comparison parameters.

[0040] In some embodiments, operation **207** includes operating the image analysis AI model **149** to automatically identify a given distinguishing feature within a given image by determining an outline and content of the given distinguishing feature within the given image. In some embodiments, operation **207** includes operating the image analysis AI model **149** to automatically identify pixels associated with the outline and content of the given distinguishing feature within the given image. In some embodiments, operation **207** includes operating the image analysis AI model **149** to automatically identify and characterize a first set of one or more distinguishing features within the reference image **107**, and to automatically identify and characterize a second set of one or more distinguishing features within the trial image **109**. In some embodiments, the operation **207** also includes operating the image analysis AI model **149** to automatically classify and label identified candidate features within the reference image **107**, and filter the classified and labeled candidate features within the reference image **107** in accordance with a number of filter parameters to determine the first set of one or more distinguishing features within the reference image **107**. Also, in these embodiments, the operation **207** includes operating the image analysis AI model **149** to automatically classify and label identified candidate features within the trial image **109**, and filter the classified and labeled candidate features within the trial image **109** in accordance with the number of filter parameters to determine the second set of one or more distinguishing features within the trial image **109**. In some embodiments, the number of filter parameters includes a minimum size for a given distinguishing feature within a given image, where the minimum size is specified as either a percentage of a total size of the given image occupied by the given distinguishing feature, or as a total number of pixels used to display the given distinguishing feature within the given image.

[0041] From the operation **207**, the method proceeds with an operation **209**, as indicated by arrow **208**, to determine whether or not the current image match score **151** is greater than or equal to the minimum required image match score **143**. If the current image match score **151** is not greater than or equal to the minimum required image match score **143**, the method proceeds with an operation **211**, as indicated by arrow **212**, for determining whether or not the trial iteration counter **150** is equal to the maximum allowed number of iterations **153**. If the trial iteration counter **150** is not equal to the maximum allowed number of iterations **153**, the method proceeds with an operation **213**, as indicated by arrow **216**, for operating the trial input specification adjustment engine **115** to generate a revised version of the trial input specification **148** for use in generation of a new version of the trial image **109** by the second AI-based image generation system **105** that provides for an increase of the image match score **151**. Also, as part of the operation **213**, the method includes incrementing the trial iteration counter **150** by one.

[0042] From the operation **213**, the method proceeds back to the operation **205**, as indicated by arrow **220**. In this manner, the method continues with the next iteration of operating the second AI-based image generation system **105** to generate the new version of the trial image **109** and assessing the matching of the new version of the trial image **109** to the reference image **107**, with corresponding computing of the image match score **151** for the new version of the trial image **109**, and with corresponding determination of whether or not the minimum required image match score **143** is met or exceeded by the image match score **151** for the new version of the trial image **109**.

[0043] With reference back to operation **211**, if the trial iteration counter **150** is equal to the maximum allowed number of iterations **153**, the method proceeds with an operation **219**, as indicated by arrow **214**, for operating the reference input specification adjustment engine **113** to generate a revised version of the reference input specification **146**. The operation **219** also includes resetting the trial iteration counter **150** to zero. From the operation **219**, the method proceeds back to the operation **203**, as indicated by arrow **220**, for operating the first AI-based image generation system **103** to generate a new current version of the reference image **107** based on the revised version of the reference input specification **146**. Also, from the operation **210**, the method proceeds back to the operation **205**, as indicated by arrow **222**, for operating the second AI-based image generation system **105** to generate a new current version of the trial image **109** based on a current version of the trial input specification **148** that is set equal to the revised version of the reference input specification **146**. Also, with reference back to operation **209**, if the current image match score **151** is greater than or equal to the minimum required image match score **143**, the method proceeds with an operation **217**, as indicated by arrow **210**, for formatting and conveying as output each of the current reference input specification **146**, the current reference image **107**, the current trial input specification **148**, the current trial image **109**, and the current image match score **151**.

[0044] FIG. **3**A shows an example of the initial inputs received in the operation **201** through the input processor

101, in accordance with some embodiments. The example initial inputs include the initial input for AI-based image generation **141**, the minimum required image match score **143**, and the maximum allowed number of iterations **153**. By way of non-limiting example, the initial input for AI-based image generation **141** is specified as "castle with one tower and drawbridge and moat and winding road." Also, by way of non-limiting example, the minimum required image match score **143** is specified as 80%. Also, by way of non-limiting example, the maximum allowed number of iterations **153** is specified as 20. FIG. **3**A also shows an example of the reference image **107** generated in the operation **203** by the first AI-based image generation system **103** using the initial input for AI-based image generation **141** as the reference input specification **146**.

[0045] FIG. **3**B shows an example first set of distinguishing features within the example reference image **107**, as identified in the operation **207** by the image analysis AI model **149** of the image matching assessment system **111**, in accordance with some embodiments. The example first set of distinguishing features within the example reference image **107** include a feature **381** classified as a "tower" and labeled as "center tower." The example first set of distinguishing features within the example reference image **107** also include a feature **382** classified as a "tower" and labeled as "corner tower." The example first set of distinguishing features within the example reference image **107** also include a feature **383** classified as a "tower" and labeled as "corner tower." The example first set of distinguishing features within the example reference image **107** also include a feature **384** classified as a "tower" and labeled as "detached tower." The example first set of distinguishing features within the example reference image **107** also include a feature **385** classified as a "entrance" and labeled as "archway." The example first set of distinguishing features within the example reference image **107** also include a feature **386** classified as a "stairs" and labeled as "side staircase." The example first set of distinguishing features within the example reference image **107** also include a feature **387** classified as a "pathway" and labeled as "entrance path." The example first set of distinguishing features within the example reference image **107** also include a feature **388** classified as a "tree" and labeled as "front-side tree." The example first set of distinguishing features within the example reference image **107** also include a feature **389** classified as a "tree" and labeled as "front-side tree." The example first set of distinguishing features within the example reference image **107** also include a feature **390** classified as a "grass" and labeled as "front lawn." The example first set of distinguishing features within the example reference image **107** also include a feature **391** classified as a "grass" and labeled as "front lawn." The example first set of distinguishing features within the example reference image **107** also include a feature **392** classified as a "water" and labeled as "front pond."

[0046] FIG. **3**C shows the trial input specification **148** and corresponding trial image **109**, as generated by the second AI-based image generation system **105**, for a first trial image **109** generation and assessment iteration by the system **100**, in accordance with some embodiments. For the first trial image **109** generation and assessment iteration, the trial input specification **148** is initialized to the initial input for AI-based image generation **141** as received through the input processor **101**. FIG. **3**C shows that the current image match score **151** for the current trial image **109** of the first iteration is 43%. Because the current image match score **151** of 43% is less than the minimum required image match score **143** of 80%, the system **100** proceeds with another trial image **109** generation and assessment iteration.

[0047] FIG. **3**D shows the trial input specification **148** and corresponding trial image **109**, as generated by the second AI-based image generation system **105**, for a second trial image **109** generation and assessment iteration by the system **100**, in accordance with some embodiments. For the second trial image **109** generation and assessment iteration, the trial input specification **148** is revised by the trial input specification adjustment engine **115** from the trial input specification **148** used in the first trial image **109** generation and assessment iteration. The revised trial input specification **148** is based on the differences between the current trial image **109** and the current reference image **107** as determined by the image analysis AI model **149** of the image matching assessment system **111** during the second trial image **109** generation and assessment iteration. FIG. **3**D shows that the current image match score **151** for the current trial image **109** of the second iteration improved from 43% to 68%. Because the current image match score **151** of 68% is less than the minimum required image match score **143** of 80%, the system **100** proceeds with another trial image **109** generation and assessment iteration.

[0048] FIG. **3**E shows the trial input specification **148** and corresponding trial image **109**, as generated by the second AI-based image generation system **105**, for a third trial image **109** generation and assessment iteration by the system **100**, in accordance with some embodiments. For the third trial image **109** generation and assessment iteration, the trial input specification **148** is revised by the trial input specification adjustment engine **115** from the trial input specification **148** used in the second trial image **109** generation and assessment iteration. The revised trial input specification **148** is based on the differences between the current trial image **109** and the current reference image **107** as determined by the image analysis AI model **149** of the image matching assessment system **111** during the third trial image **109** generation and assessment iteration. FIG. **3**E shows that the current image match score **151** for the current trial image **109** of the third iteration declined from 68% to 52%. Because the current image match score **151** of 52% is less than the minimum required image match score **143** of 80%, the system **100** proceeds with another trial image **109** generation and assessment iteration.

[0049] FIG. **3**F shows the trial input specification **148** and corresponding trial image **109**, as generated by the second AI-based image generation system **105**, for a fourth trial image **109** generation and assessment iteration by the system **100**, in accordance with some embodiments. For the fourth trial image **109** generation and assessment iteration, the trial input specification **148** is revised by the trial input specification adjustment engine **115** from the trial input specification **148** used in the third trial image **109** generation and assessment iteration. The revised trial input specification **148** is based on the differences between the current trial image **109** and the current reference image **107** as determined by the image analysis AI model **149** of the image matching assessment system **111** during the fourth trial image **109** generation and assessment iteration. FIG. **3**F shows that the current image match score **151** for the current

trial image **109** of the fourth iteration improved from 52% to 77%. Because the current image match score **151** of 77% is less than the minimum required image match score **143** of 80%, the system **100** proceeds with another trial image **109** generation and assessment iteration.

[0050] FIG. **3**G shows the trial input specification **148** and corresponding trial image **109**, as generated by the second AI-based image generation system **105**, for a fifth trial image **109** generation and assessment iteration by the system **100**, in accordance with some embodiments. For the fifth trial image **109** generation and assessment iteration, the trial input specification **148** is revised by the trial input specification adjustment engine **115** from the trial input specification **148** used in the fourth trial image **109** generation and assessment iteration. The revised trial input specification **148** is based on the differences between the current trial image **109** and the current reference image **107** as determined by the image analysis AI model **149** of the image matching assessment system **111** during the fifth trial image **109** generation and assessment iteration. FIG. **3**G shows that the current image match score **151** for the current trial image **109** of the fifth iteration improved from 77% to 82%. Because the current image match score **151** of 82% is greater than the minimum required image match score **143** of 80%, the system **100** proceeds to engage the output processor **119** to format and convey as output (to the user of the system **100**) each of the current version of the reference input specification **146**, the current version of the reference image **107**, the current version of the trial input specification **148**, the current version of the trial image **109**, and the current image match score **151**.

[0051] FIG. **3**H shows an example second set of distinguishing features within the example trial image **109** of the fifth iteration, as identified in the operation **207** by the image analysis AI model **149** of the image matching assessment system **111**, in accordance with some embodiments. The example second set of distinguishing features within the example trial image **109** include a feature **361** classified as a "tower" and labeled as "center tower." The example second set of distinguishing features within the example trial image **109** also include a feature **362** classified as a "tower" and labeled as "corner tower." The example second set of distinguishing features within the example trial image **109** also include a feature **363** classified as a "tower" and labeled as "corner tower." The example second set of distinguishing features within the example trial image **109** also include a feature **365** classified as a "entrance" and labeled as "archway." The example second set of distinguishing features within the example trial image **109** also include a feature **366** classified as a "stairs" and labeled as "side staircase." The example second set of distinguishing features within the example trial image **109** also include a feature **367** classified as a "pathway" and labeled as "entrance path." The example second set of distinguishing features within the example trial image **109** also include a feature **368** classified as a "tree" and labeled as "front-side tree." The example second set of distinguishing features within the example trial image **109** also include a feature **369** classified as a "tree" and labeled as "front-side tree." The example second set of distinguishing features within the example trial image **109** also include a feature **370** classified as a "grass" and labeled as "front lawn." The example second set of distinguishing features within the example trial image **109** also include a feature **371** classified as a "grass" and labeled as "front lawn." The example second set of distinguishing features within the example trial image **109** also include a feature **372** classified as a "water" and labeled as "front pond." Therefore, in comparing the second set of distinguishing features within the example trial image **109** of the fifth iteration with the first set of distinguishing features within the example reference image **107**, as shown in FIG. **3**B, the primary difference is the absence of the "detached tower" in the trial image **109**. However, the feature-to-feature similarities between the example first set of distinguishing features within the example reference image **107** and the example second set of distinguishing features within the example trial image **109** yield a current image match score **151** of 82% is sufficient to satisfy the minimum required image match score **143** of 80% in the present example.

[0052] FIG. **3**I shows the outputs as formatted and conveyed by the output processor **119** for the example operation of the system **100** as shown in FIGS. **3**A-**3**H, in accordance with some embodiments. The outputs include the current/final version of the reference input specification **146** and the corresponding current/final version of the reference image **107**. The outputs also include the current/final version of the trial input specification **148** and the corresponding current/final version of the trial image **109**, and the corresponding current/final image match score **151**. In some embodiments, the user of the system **100** is able to direct the output processor **119** to output the current version of the reference input specification **146**, the current version of the reference image **107**, the current version of the trial input specification **148**, the current version of the trial image **109**, and the current image match score **151**, for each trial image **109** generation and assessment iteration that is performed. In some embodiments, the user of the system **100** is able to direct the output processor **119** to output the current version of the reference input specification **146**, the current version of the reference image **107**, the current version of the trial input specification **148**, the current version of the trial image **109**, and the current image match score **151**, for selected trial image **109** generation and assessment iterations that are performed. In some embodiments, the user of the system **100** is able to direct the output processor **119** to output the current version of the reference input specification **146**, the current version of the reference image **107**, the current version of the trial input specification **148**, the current version of the trial image **109**, and the current image match score **151**, for just the final trial image **109** generation and assessment iteration that is performed.

[0053] FIG. **4** shows various components of an example server device **400** within a cloud-based computing system that can be used to perform aspects of the system **100** and method for aligning outputs of different artificial AI-based image generation systems, in accordance with some embodiments. This block diagram illustrates the server device **400** that can incorporate or can be a personal computer, video game console, personal digital assistant, a head mounted display (HMD), a wearable computing device, a laptop or desktop computing device, a server or any other digital computing device, suitable for practicing an embodiment of the disclosure. The server device (or simply referred to as "server" or "device") **400** includes a central processing unit (CPU) **402** for running software applications and optionally an operating system. The CPU **402** may be comprised of one or more homogeneous or heterogeneous processing cores. For example, the CPU **402** is one or more general-purpose

microprocessors having one or more processing cores. Further embodiments can be implemented using one or more CPUs with microprocessor architectures specifically adapted for highly parallel and computationally intensive applications, such as processing operations of interpreting a query, identifying contextually relevant resources, and implementing and rendering the contextually relevant resources in a video game immediately. Device **400** may be localized to a designer designing a game segment or remote from the designer (e.g., back-end server processor), or one of many servers using virtualization in the cloud-based gaming system **400** for remote use by designers.

[0054] Memory **404** stores applications and data for use by the CPU **402**. Storage **406** provides non-volatile storage and other computer readable media for applications and data and may include fixed disk drives, removable disk drives, flash memory devices, and CD-ROM, DVD-ROM, Blu-ray, HD-DVD, or other optical storage devices, as well as signal transmission and storage media. User input devices **408** communicate user inputs from one or more users to device **400**, examples of which may include keyboards, mice, joysticks, touch pads, touch screens, still or video recorders/cameras, tracking devices for recognizing gestures, and/or microphones. Network interface **414** allows device **400** to communicate with other computer systems via an electronic communications network, and may include wired or wireless communication over local area networks and wide area networks such as the internet. An audio processor **412** is adapted to generate analog or digital audio output from instructions and/or data provided by the CPU **402**, memory **404**, and/or storage **406**. The components of device **400**, including CPU **402**, memory **404**, data storage **406**, user input devices **408**, network interface **414**, and audio processor **412** are connected via one or more data buses **422**.

[0055] A graphics subsystem **420** is further connected with data bus **422** and the components of the device **400**. The graphics subsystem **420** includes a graphics processing unit (GPU) **416** and graphics memory **418**. Graphics memory **418** includes a display memory (e.g., a frame buffer) used for storing pixel data for each pixel of an output image. Graphics memory **418** can be integrated in the same device as GPU **416**, connected as a separate device with GPU **416**, and/or implemented within memory **404**. Pixel data can be provided to graphics memory **418** directly from the CPU **402**. Alternatively, CPU **402** provides the GPU **416** with data and/or instructions defining the desired output images, from which the GPU **416** generates the pixel data of one or more output images. The data and/or instructions defining the desired output images can be stored in memory **404** and/or graphics memory **418**. In an embodiment, the GPU **416** includes 3D rendering capabilities for generating pixel data for output images from instructions and data defining the geometry, lighting, shading, texturing, motion, and/or camera parameters for virtual object(s) within a scene. The GPU **416** can further include one or more programmable execution units capable of executing shader programs.

[0056] The graphics subsystem **420** periodically outputs pixel data for an image from graphics memory **418** to be displayed on display device **410**. Display device **410** can be any device capable of displaying visual information in response to a signal from the device **400**, including CRT, LCD, plasma, and OLED displays. In addition to display device **410**, the pixel data can be projected onto a projection surface. Device **400** can provide the display device **410** with an analog or digital signal, for example.

[0057] Implementations of the present disclosure for the systems and methods for aligning outputs of different artificial AI-based image generation systems may be practiced using various computer device configurations including hand-held devices, microprocessor systems, microprocessor-based or programmable consumer electronics, minicomputers, mainframe computers, head-mounted display, wearable computing devices and the like. Embodiments of the present disclosure can also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a wire-based or wireless network.

[0058] With the above embodiments in mind, it should be understood that the disclosure can employ various computer-implemented operations involving data stored in computer systems. These operations are those requiring physical manipulation of physical quantities. Any of the operations described herein that form part of the disclosure are useful machine operations. The disclosure also relates to a device or an apparatus for performing these operations. The apparatus can be specially constructed for the required purpose, or the apparatus can be a general-purpose computer selectively activated or configured by a computer program stored in the computer. In particular, various general-purpose machines can be used with computer programs written in accordance with the teachings herein, or it may be more convenient to construct a more specialized apparatus to perform the required operations.

[0059] Although various method operations were described in a particular order, it should be understood that other housekeeping operations may be performed in between the method operations. Also, method operations may be adjusted so that they occur at slightly different times or in parallel with each other. Also, method operations may be distributed in a system which allows the occurrence of the processing operations at various intervals associated with the processing.

[0060] One or more embodiments can also be fabricated as computer readable code (program instructions) on a computer readable medium. The computer readable medium is any data storage device that can store data, which can be thereafter be read by a computer system. Examples of the computer readable medium include hard drives, network attached storage (NAS), read-only memory, random-access memory, CD-ROMs, CD-Rs, CD-RWs, magnetic tapes and other optical and non-optical data storage devices, or any other type of device that is capable of storing digital data. The computer readable medium can include computer readable tangible medium distributed over a network-coupled computer system so that the computer readable code is stored and executed in a distributed fashion.

[0061] Although the foregoing embodiments have been described in some detail for purposes of clarity of understanding, it will be apparent that certain changes and modifications can be practiced within the scope of the appended claims. Accordingly, the present embodiments are to be considered as illustrative and not restrictive, and the embodiments are not to be limited to the details given herein, but may be modified within the scope and equivalents of the appended claims.

[0062] It should be understood that the various embodiments defined herein may be combined or assembled into

specific implementations using the various features disclosed herein. Thus, the examples provided are just some possible examples, without limitation to the various implementations that are possible by combining the various elements to define many more implementations. In some examples, some implementations may include fewer elements, without departing from the spirit of the disclosed or equivalent implementations.

What is claimed is:

1. A system for aligning outputs of different artificial intelligence (AI)-based image generation systems, comprising:

an input processor configured to receive an initial input for AI-based image generation, the input processor configured to receive a specification of a minimum required image match score;

a first AI-based image generation system configured to generate a reference image based on a reference input specification, wherein the reference input specification is initially set equal to the initial input for AI-based image generation;

a second AI-based image generation system configured to generate a trial image based on a trial input specification, the second AI-based image generation system being different than the first AI-based image generation system, wherein the trial input specification is initially set equal to the initial input for AI-based image generation;

an image matching assessment system configured to process the trial image and the reference image through an image analysis AI model to determine an amount of similarity between the trial image and the reference image, the image matching assessment system configured to generate an image match score based on the determined amount of similarity between the trial image and the reference image;

a trial input specification adjustment engine configured to generate a revised version of the trial input specification for use in generation of a new version of the trial image by the second AI-based image generation system that provides for an increase of the image match score;

a controller configured to direct iterative operation of the second AI-based image generation system, the image matching assessment system, and the trial input specification adjustment engine until the image match score is equal to or greater than the minimum required image match score; and

an output processor configured to format and convey as output each of the reference input specification, the reference image, the trial input specification, the trial image, and the image match score when the image match score is equal to or greater than the minimum required image match score.

2. The system as recited in claim **1**, wherein the first AI-based image generation system includes one or more image generation AI models configured to generate a first genre of graphical image, and wherein the second AI-based image generation system includes one or more image generation AI models configured to generate a second genre of graphical image, the second genre different from the first genre.

3. The system as recited in claim **1**, wherein each of the initial input for AI-based image generation, the reference input specification, and the trial input specification is a respective linguistic description of an image.

4. The system as recited in claim **1**, wherein the image matching assessment system is configured to automatically identify a given distinguishing feature within a given image by determining an outline of the given distinguishing feature within the given image.

5. The system as recited in claim **4**, wherein the image analysis AI model is configured to implement a pixel-level analysis of the given image to automatically identify pixels associated with the outline of the given distinguishing feature within the given image.

6. The system as recited in claim **1**, wherein the image analysis AI model is configured to analyze the reference image to identify and characterize a first set of one or more distinguishing features within the reference image, and wherein the image analysis AI model is also configured to analyze the trial image to identify and characterize a second set of one or more distinguishing features within the trial image.

7. The system as recited in claim **6**, wherein the image analysis AI model is configured to classify and label identified candidate features within the reference image, the image matching assessment system configured to filter the classified and labeled candidate features within the reference image in accordance with a number of filter parameters to determine the first set of one or more distinguishing features within the reference image, and wherein the image analysis AI model is configured to classify and label identified candidate features within the trial image, the image matching assessment system configured to filter the classified and labeled candidate features within the trial image in accordance with the number of filter parameters to determine the second set of one or more distinguishing features within the trial image.

8. The system as recited in claim **7**, wherein the number of filter parameters includes a minimum size for a given distinguishing feature within a given image specified as one or more of a percentage of a total size of the given image occupied by the given distinguishing feature and a total number of pixels used to display the given distinguishing feature within the given image.

9. The system as recited in claim **1**, wherein the image matching assessment system is configured to generate the image match score by evaluating a number of comparison parameters for correlated distinguishing features in the reference image and the trial image, the number of comparison parameters including one or more of a feature size, a feature shape, a feature contextual position, a feature spatial orientation, a feature texture, a feature color, a feature-to-feature relationship, a pixel intensity gradient, a pixel color, and a pixel-level color gradient.

10. The system as recited in claim **1**, further comprising:

a reference input specification adjustment engine configured to generate a revised version of the reference input specification for use in generation of a new version of the reference image by the first AI-based image generation system, wherein the controller is configured to increment a trial iteration counter for each time the second AI-based image generation system generates the new version of the trial image based on the revised version of the trial input specification as generated by the trial input specification adjustment engine, the controller further configured to direct the reference

input specification adjustment engine to generate the revised version of the reference input specification and to direct the first AI-based image generation system to generate the new version of the reference image when the trial iteration counter exceeds a maximum iteration value.

11. A method for aligning outputs of different artificial intelligence (AI)-based image generation systems, comprising:

a) receiving an initial input for AI-based image generation;

b) receiving a specification of a minimum required image match score;

c) operating a first AI-based image generation system to generate a reference image based on a reference input specification, wherein the reference input specification is initially set equal to the initial input for AI-based image generation;

d) operating a second AI-based image generation system to generate a trial image based on a trial input specification, the second AI-based image generation system being different than the first AI-based image generation system, wherein the trial input specification is initially set equal to the initial input for AI-based image generation;

e) processing the trial image and the reference image through an image analysis AI model to determine an amount of similarity between the trial image and the reference image;

f) generating an image match score for the trial image based on the amount of similarity between the trial image and the reference image as determined in operation e);

g) if the image match score is less than the minimum required image match score, then operating a trial input specification adjustment engine to generate a revised version of the trial input specification for use in generation of a new version of the trial image by the second AI-based image generation system that provides for an increase of the image match score, followed by sequentially repeating operations d), e), f), and g), and if the image match score is greater than or equal to the minimum required image match score, then proceeding with operation h); and

h) formatting and conveying as output each of the reference input specification, the reference image, the trial input specification, the trial image, and the image match score.

12. The method as recited in claim **11**, wherein operating the first AI-based image generation system includes executing one or more image generation AI models to generate a first genre of graphical image, and wherein operating the second AI-based image generation system includes executing one or more image generation AI models to generate a second genre of graphical image, the second genre different from the first genre.

13. The method as recited in claim **11**, wherein each of the initial input for AI-based image generation, the reference input specification, and the trial input specification is a respective linguistic description of an image.

14. The method as recited in claim **11**, wherein the image analysis AI model automatically identifies a given distinguishing feature within a given image by determining an outline of the given distinguishing feature within the given image.

15. The method as recited in claim **14**, wherein the image analysis AI model automatically identifies pixels associated with the outline of the given distinguishing feature within the given image.

16. The method as recited in claim **11**, wherein the image analysis AI model automatically identifies and characterizes a first set of one or more distinguishing features within the reference image, and wherein the image analysis AI model automatically identifies and characterizes a second set of one or more distinguishing features within the trial image.

17. The method as recited in claim **16**, wherein the image analysis AI model automatically classifies and labels identified candidate features within the reference image, wherein the method further comprises filtering of the classified and labeled candidate features within the reference image in accordance with a number of filter parameters to determine the first set of one or more distinguishing features within the reference image, and

wherein the image analysis AI model automatically classifies and labels identified candidate features within the trial image, wherein the method further comprises filtering of the classified and labeled candidate features within the trial image in accordance with the number of filter parameters to determine the second set of one or more distinguishing features within the trial image.

18. The method as recited in claim **17**, wherein the number of filter parameters includes a minimum size for a given distinguishing feature within a given image, the minimum size specified as one or more of a percentage of a total size of the given image occupied by the given distinguishing feature and a total number of pixels used to display the given distinguishing feature within the given image.

19. The method as recited in claim **11**, wherein generating the image match score includes evaluating a number of comparison parameters for correlated distinguishing features in the reference image and the trial image, the number of comparison parameters including one or more of a feature size, a feature shape, a feature contextual position, a feature spatial orientation, a feature texture, a feature color, a feature-to-feature relationship, a pixel intensity gradient, a pixel color, and a pixel-level color gradient.

20. The method as recited in claim **11**, wherein operation g) further includes incrementing a trial iteration counter each time the second AI-based image generation system generates the new version of the trial image based on the revised version of the trial input specification as generated by the trial input specification adjustment engine, and wherein operation g) further includes operating a reference input specification adjustment engine to generate a revised version of the reference input specification when the trial iteration counter is equal to a maximum iteration value, followed by sequentially repeating operations c), d), e), f), and g).

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