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(54) **SYSTEMS FOR SUGGESTING CONTENT COMPONENTS**

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(51) **Int. Cl.**

G06F 40/14	(2020.01)
G06F 40/197	(2020.01)
G06F 40/186	(2020.01)
G06F 3/0482	(2013.01)

(52) **U.S. Cl.**
CPC ***G06F 40/14*** (2020.01); ***G06F 40/186*** (2020.01); ***G06F 40/197*** (2020.01); *G06F 3/0482* (2013.01)

(58) **Field of Classification Search**
CPC G06F 40/14; G06F 40/197; G06F 40/186; G06F 3/0482
See application file for complete search history.

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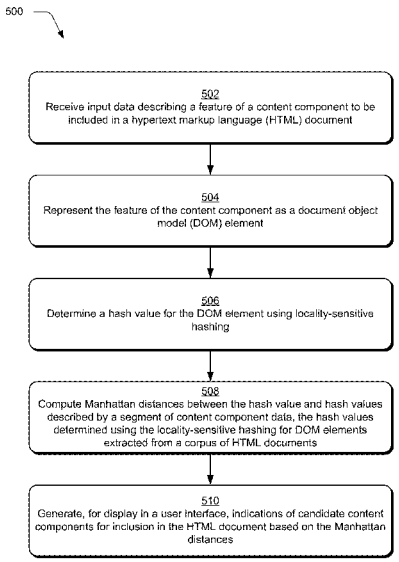
(74) *Attorney, Agent, or Firm* — FIG. 1 Patents

(57) **ABSTRACT**

In implementations of systems for suggesting content components, a computing device implements a design system to receive input data describing a feature of a content component to be included in a hypertext markup language (HTML) document. The design system represents that feature of the content component as a document object model (DOM) element and determines a hash value for the DOM element using locality-sensitive hashing. Manhattan distances are computed between the has value and has values described by a segment of content component data. The hash values were determined using the locality-sensitive hashing for DOM elements extracted from a corpus of HTML documents. The design system generates indications, for display in a user interface, of candidate content components for inclusion in the HTML document based on the Manhattan distances.

20 Claims, 11 Drawing Sheets



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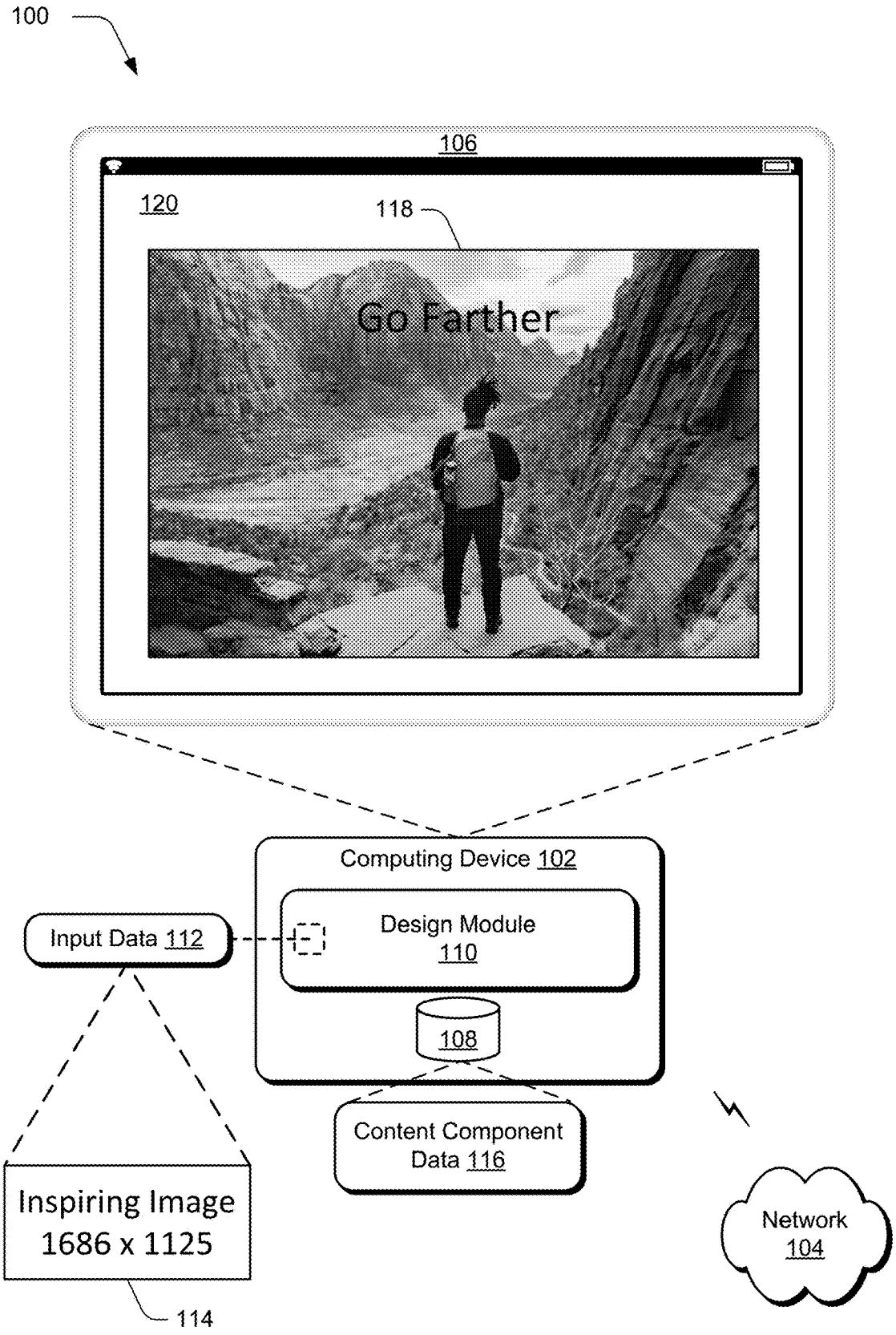

100
106
120
118
Go Farther
Computing Device 102
Design Module 110
Input Data 112
108
Content Component Data 116
Inspiring Image 1686 x 1125
114
Network 104

Fig. 1

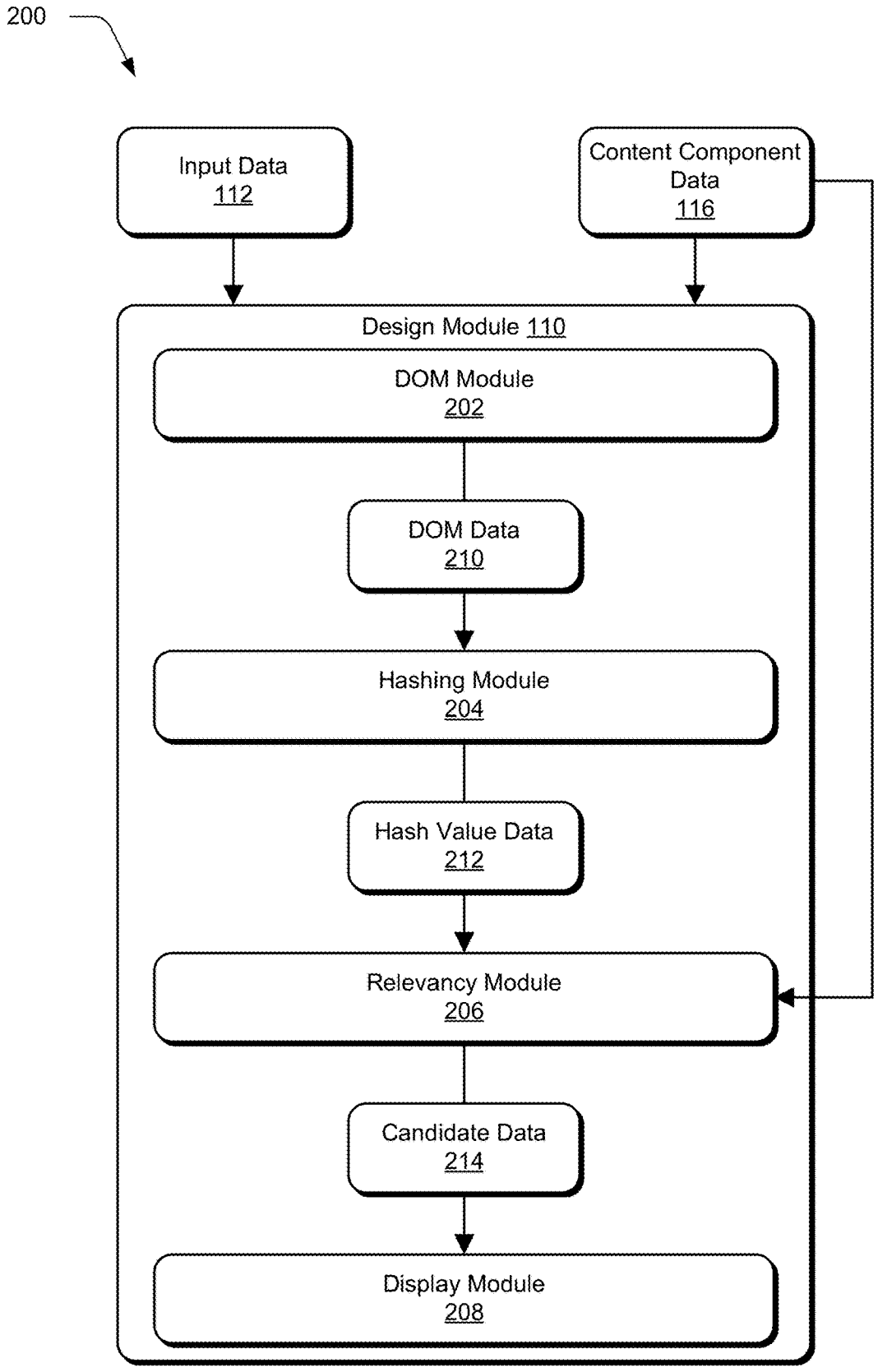

200
Input Data
112
Content Component Data
116
Design Module 110
DOM Module
202
DOM Data
210
Hashing Module
204
Hash Value Data
212
Relevancy Module
206
Candidate Data
214
Display Module
208

Fig. 2

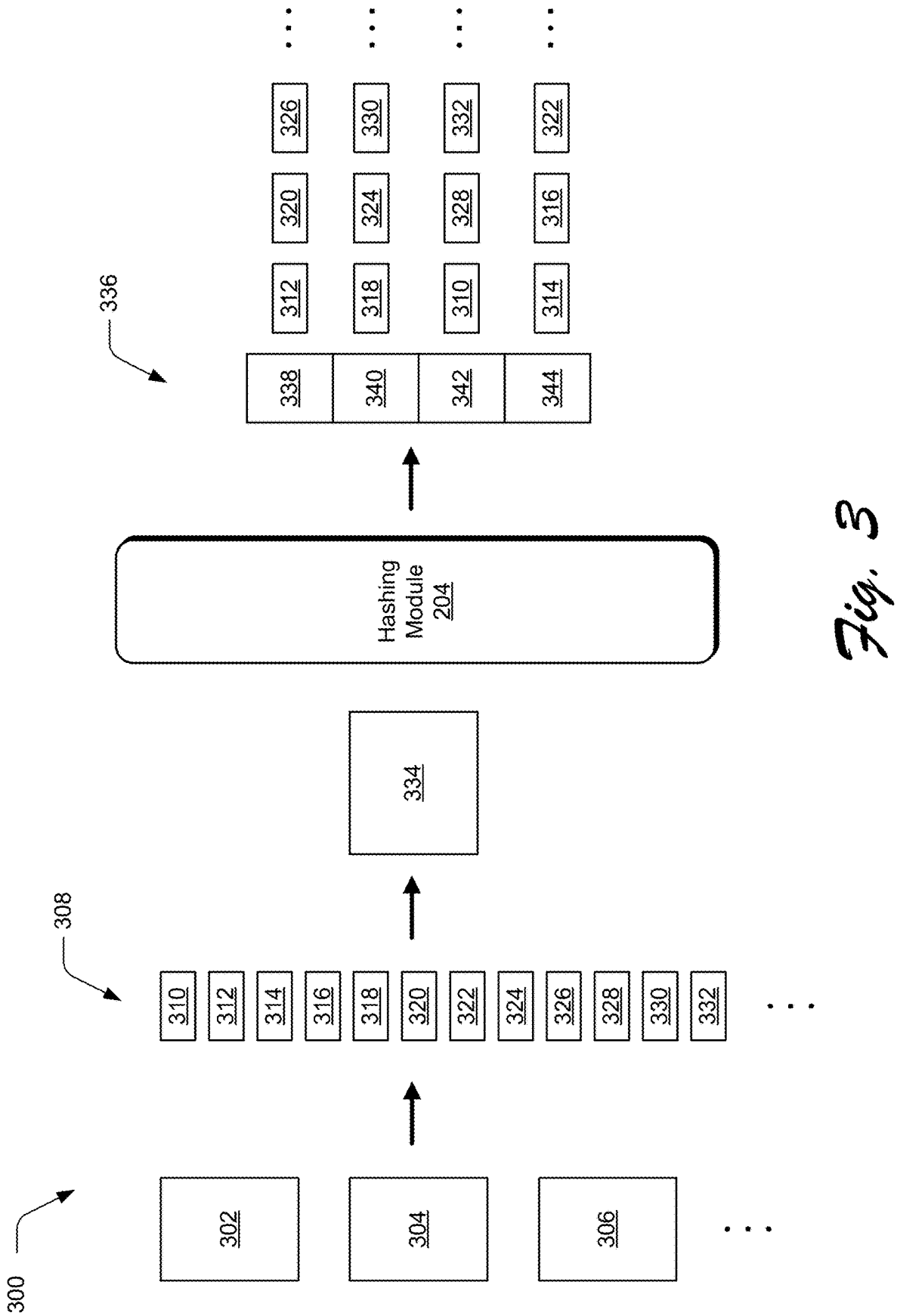

300
302
304
306
308
310
312
314
316
318
320
322
324
326
328
330
332
334
Hashing Module 204
336
338
340
342
344

Fig. 3

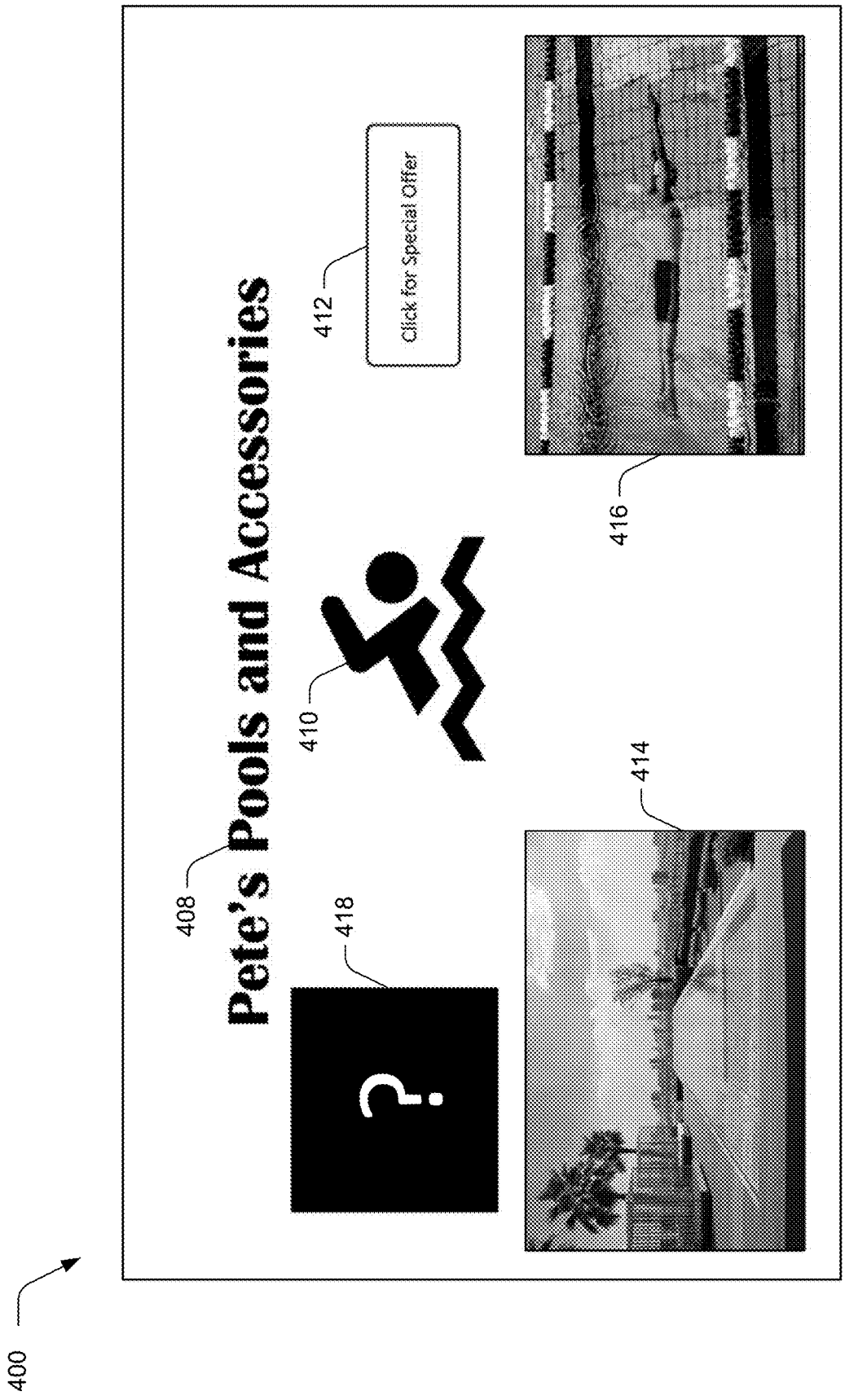
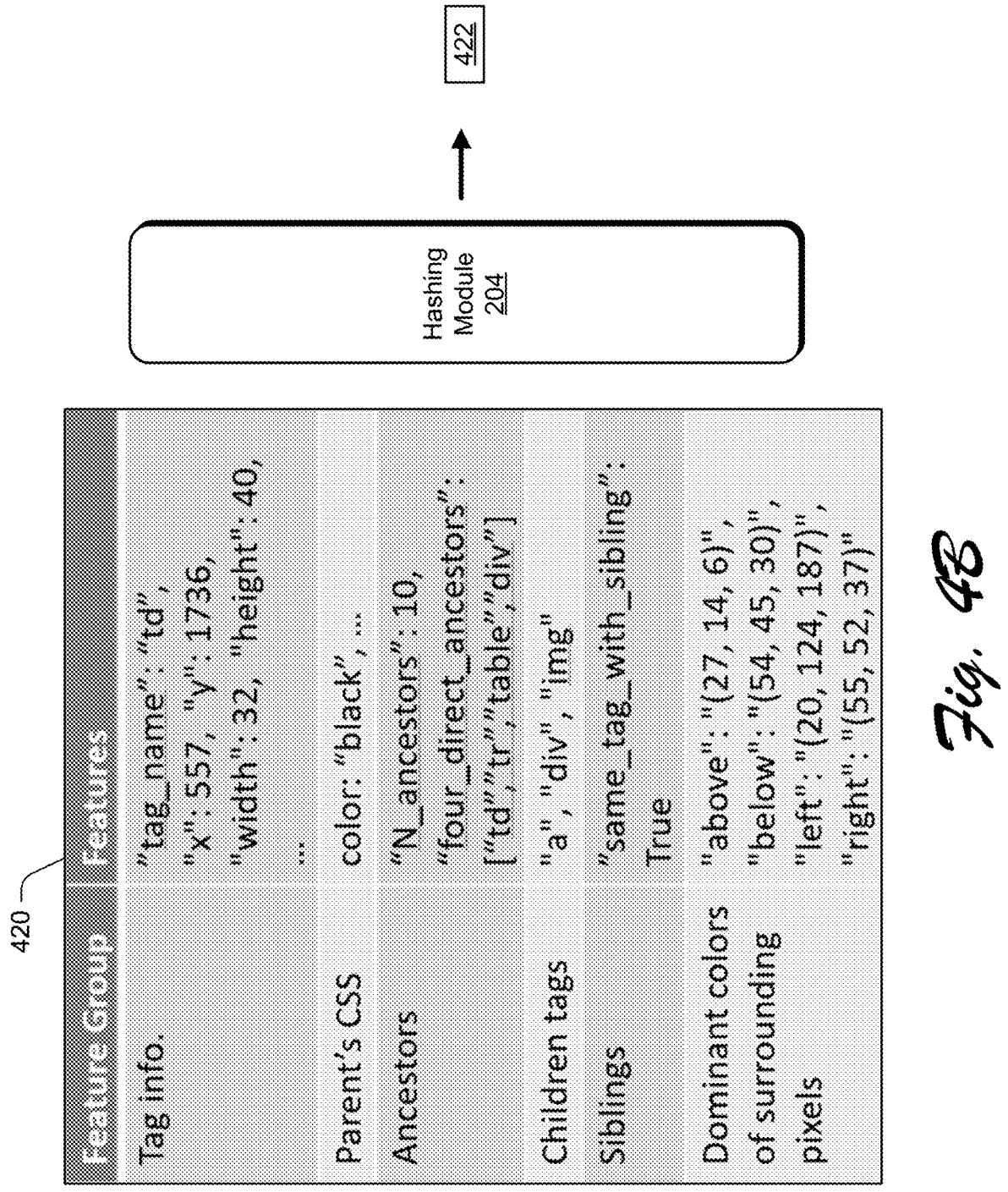

400
Pete's Pools and Accessories
408
412
Click for Special Offer
410
414
416
418
?

Fig. 4A



Feature Group	Features
Tag info.	"tag_name": "td", "x": 557, "y": 1736, "width": 32, "height": 40, ...
Parent's CSS	color: "black", ...
Ancestors	"N_ancestors": 10, "four_direct_ancestors": ["td","tr","table","div"]
Children tags	"a", "div", "img"
Siblings	"same_tag_with_sibling": True
Dominant colors of surrounding pixels	"above": "(27, 14, 6)", "below": "(54, 45, 30)", "left": "(20, 124, 187)", "right": "(55, 52, 37)"

Fig. 4B

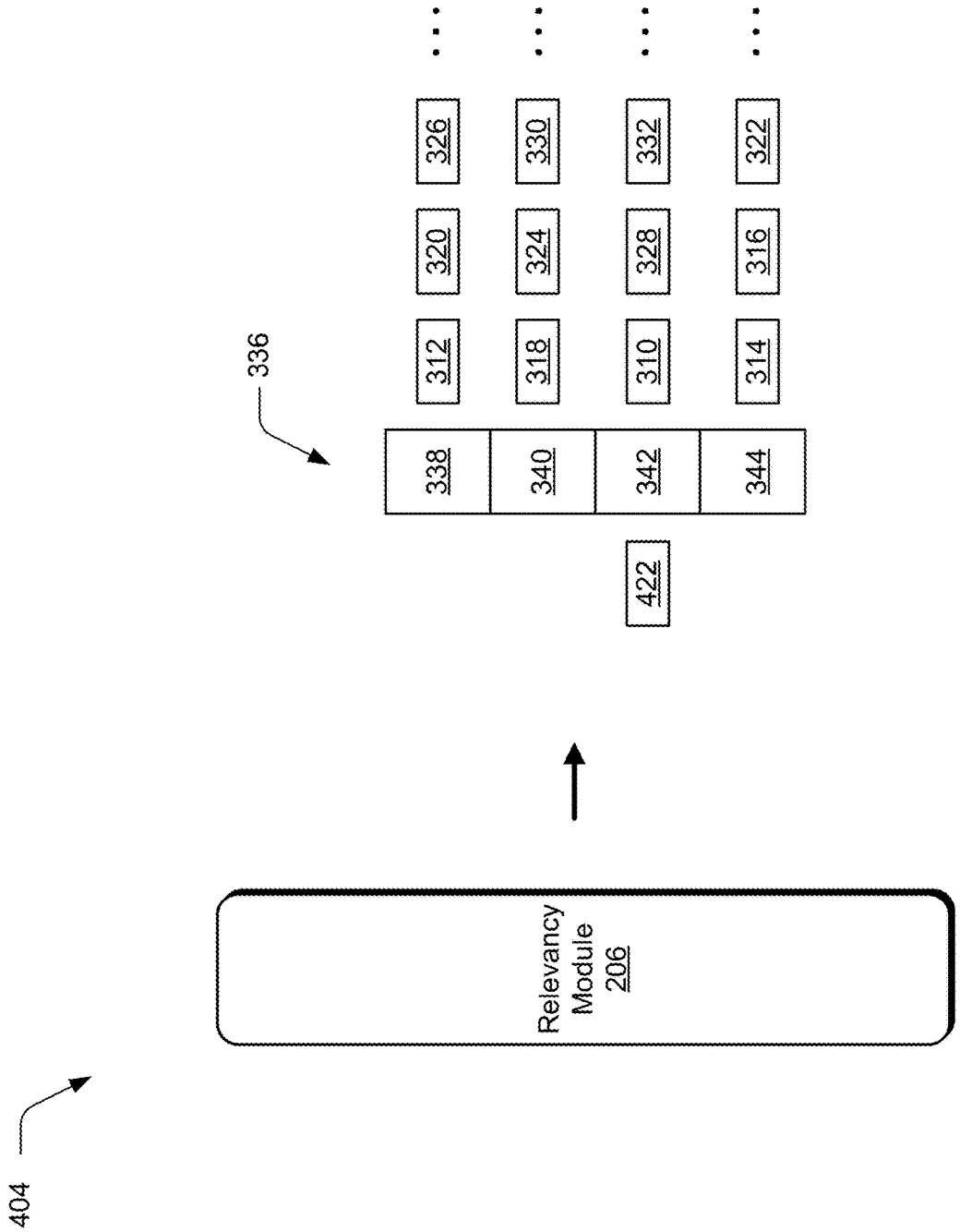

404
Relevancy Module 206
336
338
340
342
344
312
318
310
314
320
324
328
316
326
330
332
322
422

Fig. 4C

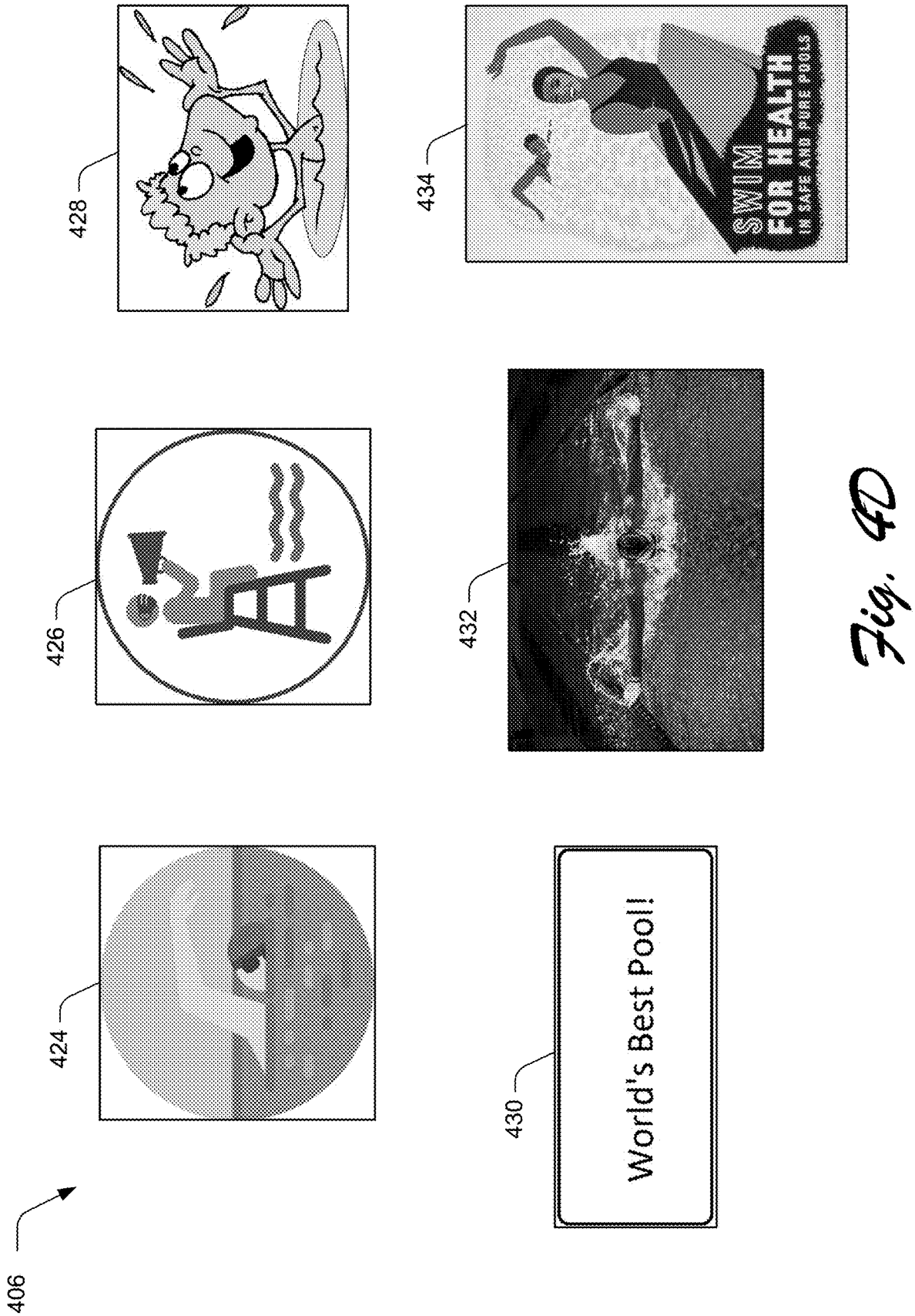

406
424
426
428
430
World's Best Pool!
432
434
SWIM
FOR HEALTH
IS SAFE AND FUN IN POOLS

Fig. 4D

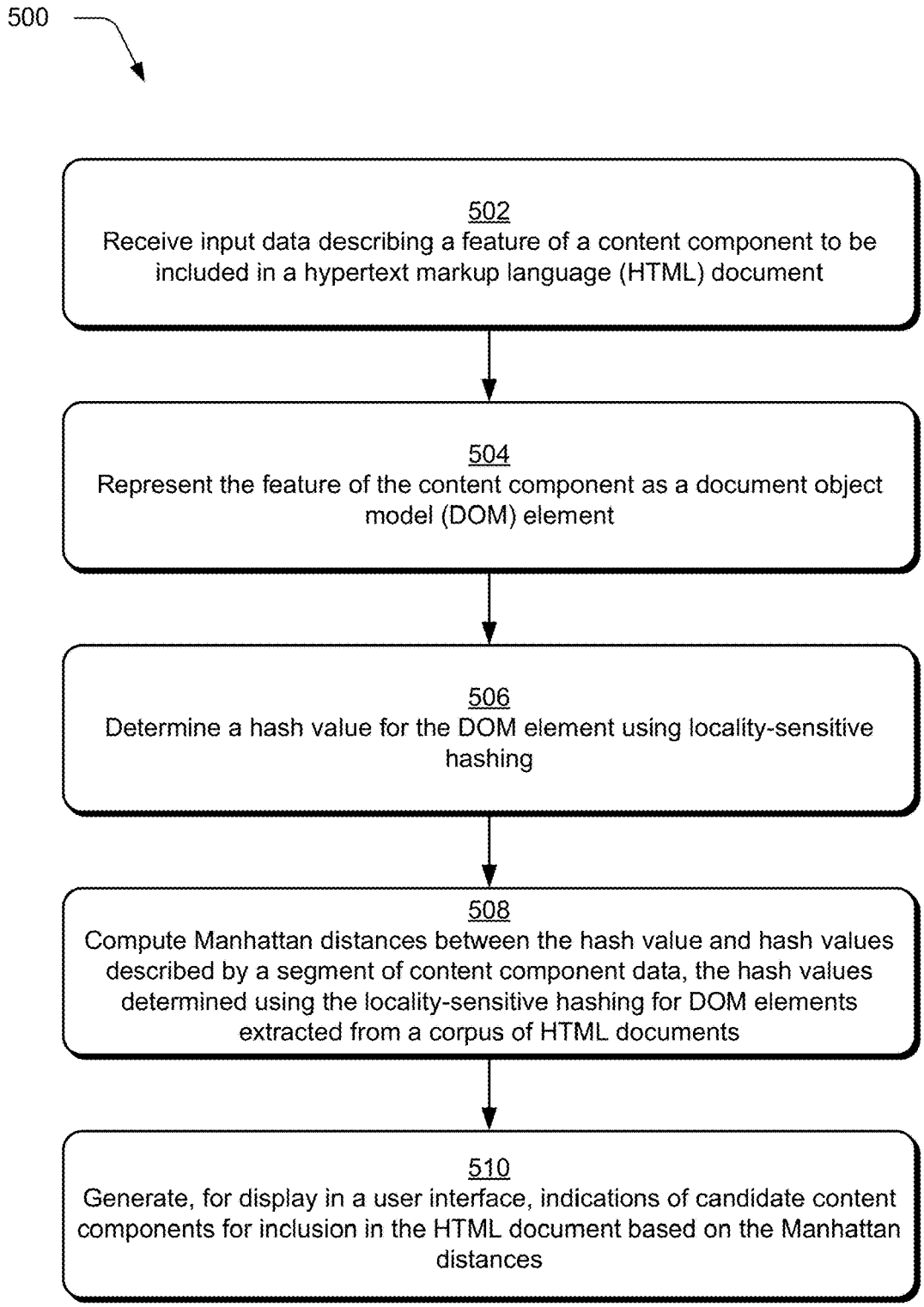
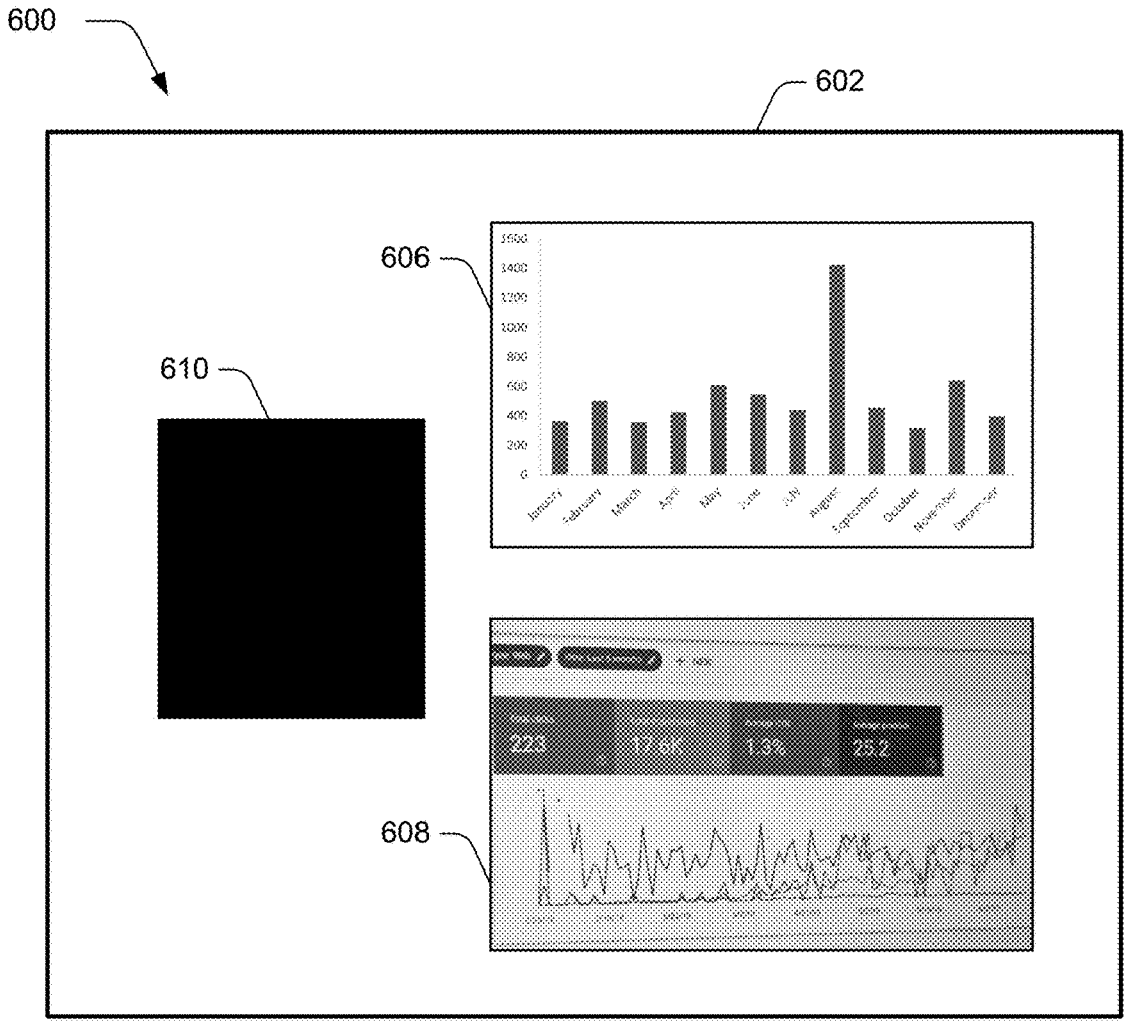

500
502
Receive input data describing a feature of a content component to be included in a hypertext markup language (HTML) document
504
Represent the feature of the content component as a document object model (DOM) element
506
Determine a hash value for the DOM element using locality-sensitive hashing
508
Compute Manhattan distances between the hash value and hash values described by a segment of content component data, the hash values determined using the locality-sensitive hashing for DOM elements extracted from a corpus of HTML documents
510
Generate, for display in a user interface, indications of candidate content components for inclusion in the HTML document based on the Manhattan distances

Fig. 5


600
602
606
610
608

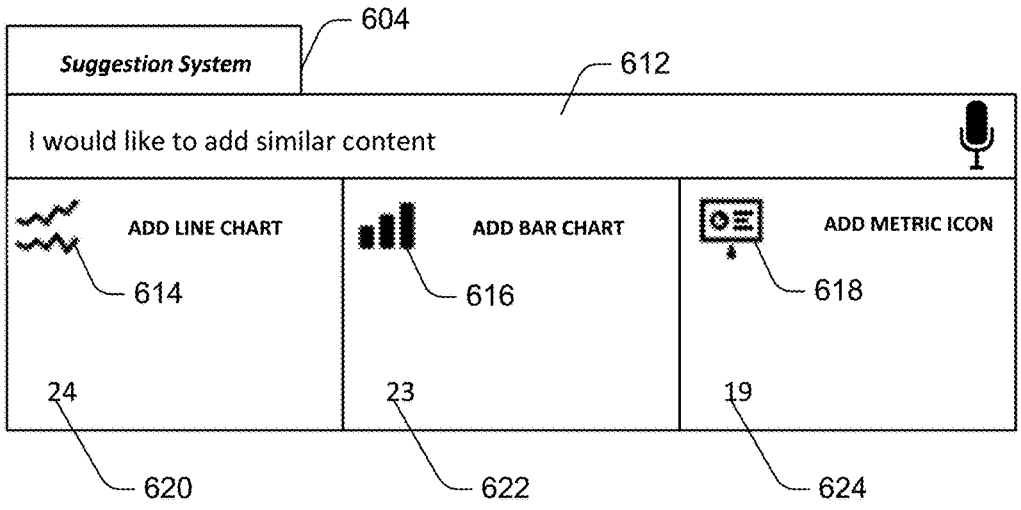

604
Suggestion System
612
I would like to add similar content
ADD LINE CHART
614
ADD BAR CHART
616
ADD METRIC ICON
618
24
620
23
622
19
624

Fig. 6

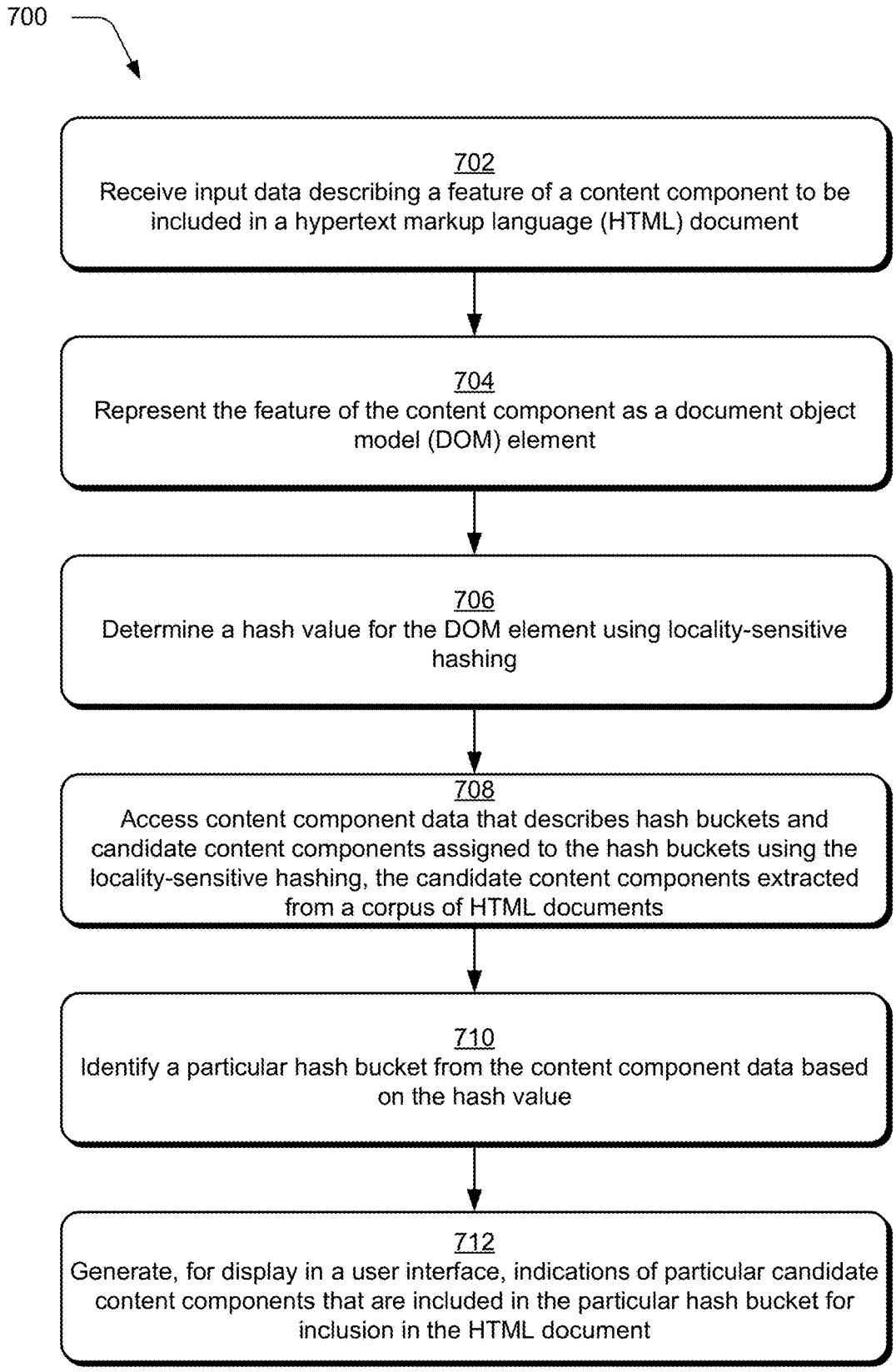

700
702
Receive input data describing a feature of a content component to be included in a hypertext markup language (HTML) document
704
Represent the feature of the content component as a document object model (DOM) element
706
Determine a hash value for the DOM element using locality-sensitive hashing
708
Access content component data that describes hash buckets and candidate content components assigned to the hash buckets using the locality-sensitive hashing, the candidate content components extracted from a corpus of HTML documents
710
Identify a particular hash bucket from the content component data based on the hash value
712
Generate, for display in a user interface, indications of particular candidate content components that are included in the particular hash bucket for inclusion in the HTML document

Fig. 7

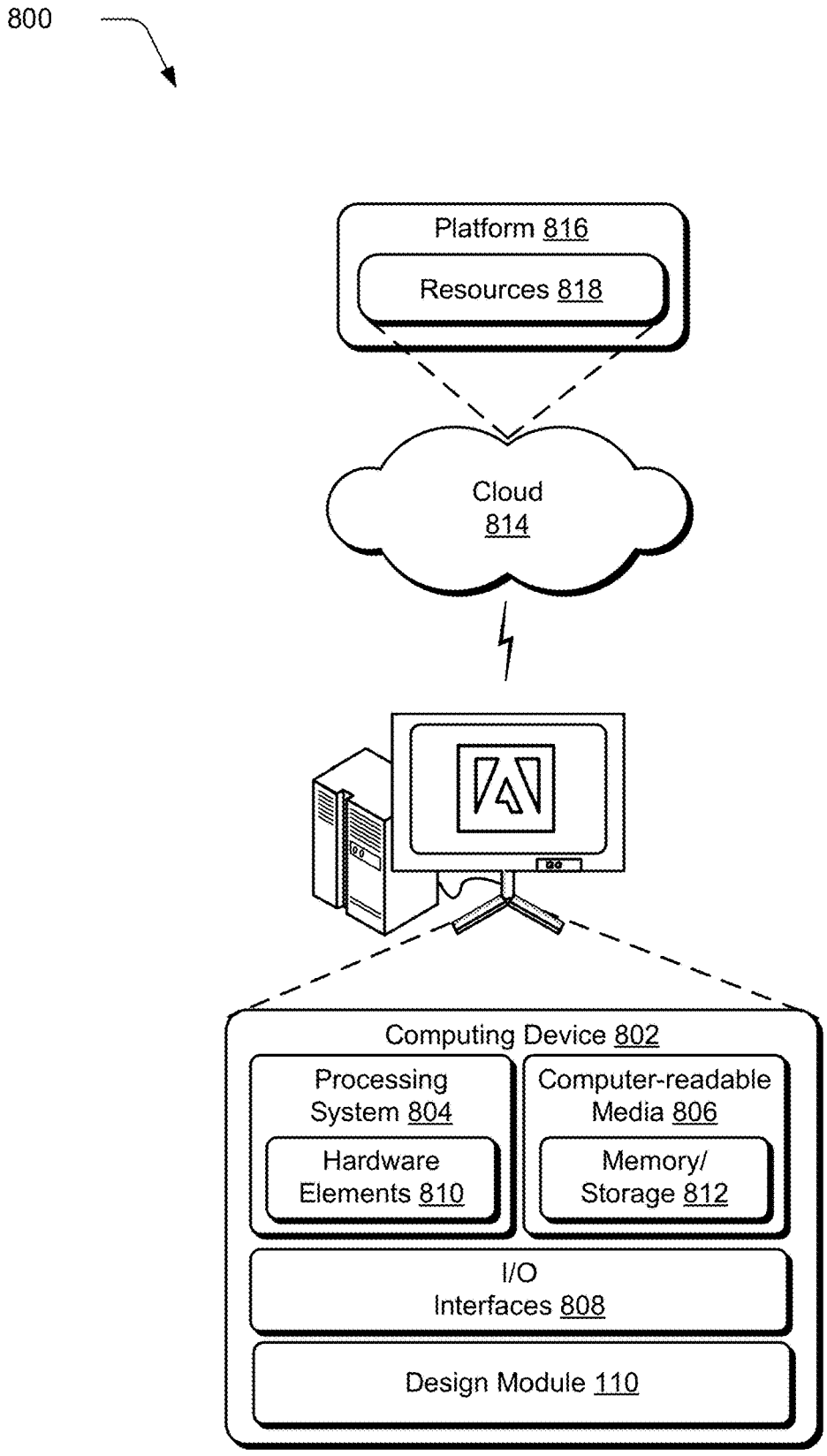

800
Platform 816
Resources 818
Cloud
814
Computing Device 802
Processing
System 804
Hardware
Elements 810
Computer-readable
Media 806
Memory/
Storage 812
I/O
Interfaces 808
Design Module 110

Fig. 8

SYSTEMS FOR SUGGESTING CONTENT COMPONENTS

RELATED APPLICATIONS

This application is a continuation of and claims priority to U.S. patent application Ser. No. 17/183,055, filed Feb. 23, 2021, entitled "Systems for Suggesting Content Components," the entire disclosure of which is hereby incorporated by reference herein in its entirety.

BACKGROUND

Systems that suggest content components for creating and/or editing digital content typically generate suggestions based on some defined measure of similarity or dissimilarity with respect to a group of candidate content components. Given an input or a query, these systems identify content components from the group that are similar or dissimilar to the input and suggest the identified content components for addition to the digital content. Conventional systems for suggesting dissimilar content components often generate suggestions which are so different from the input or the query that these suggestions are inconsistent with a design theme for the digital content and cannot be added to the digital content because of this inconsistency.

Conventional systems for suggesting similar content components frequently generate suggestions that are so similar to the input that these suggestions do not add any element of creativity or other improvement to the digital content. This shortcoming is somewhat mitigated by increasing a number and variety of candidate content components included in the group. However, these additional content components also correspond to an increase in computational resources consumed by the suggestion system to generate the suggestions such that conventional systems are unable to generate creative suggestions in substantially real time.

SUMMARY

Techniques and systems are described for suggesting content components. In an example, a computing device implements a design system to receive input data describing a feature of a content component to be included in a hypertext markup language (HTML) document. For example, the feature is a style feature, a content feature, a context feature, and so forth.

The design system represents the feature of the content component as a document object model (DOM) element and determines a hash value for the DOM element using locality-sensitive hashing based on p-stable distributions. The design system uses the hash value to identify a particular hash bucket from content component data that describes hash buckets and hash values included in the hash buckets. For example, the hash values are determined and grouped into the hash buckets using the locality-sensitive hashing based on p-stable distributions for DOM elements extracted from a corpus of HTML documents.

Manhattan distances are computed between the hash value and hash values included in the particular hash bucket. In one example, the Manhattan distances reflect a similarity between the DOM element and the DOM elements extracted from the corpus of HTML documents. The design system generates indications of candidate content components for display in a user interface based on the Manhattan distances. For example, the candidate content components are selectable for inclusion in the HTML document.

This Summary introduces a selection of concepts in a simplified form that are further described below in the Detailed Description. As such, this Summary is not intended to identify essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

The detailed description is described with reference to the accompanying figures. Entities represented in the figures are indicative of one or more entities and thus reference is made interchangeably to single or plural forms of the entities in the discussion.

FIG. **1** is an illustration of an environment in an example implementation that is operable to employ digital systems and techniques for suggesting content components as described herein.

FIG. **2** depicts a system in an example implementation showing operation of a design module for suggesting content components.

FIG. **3** illustrates an example representation of generating content component data.

FIGS. **4**A, **4**B, **4**C, and **4**D illustrate an example of suggesting content components.

FIG. **5** is a flow diagram depicting a procedure in an example implementation in which input data describing a feature of a content component to be included in a hypertext markup language (HTML) document is received and indications of candidate content components are generated for inclusion in the HTML document.

FIG. **6** illustrates an example representation of a user interface for suggesting content components.

FIG. **7** is a flow diagram depicting a procedure in an example implementation in which input data describing a feature of a content component to be included in a hypertext markup language (HTML) document is received and indications of particular candidate content components are generated for inclusion in the HTML document.

FIG. **8** illustrates an example system that includes an example computing device that is representative of one or more computing systems and/or devices for implementing the various techniques described herein.

DETAILED DESCRIPTION

Overview

Systems for suggesting content components to include in digital content generate suggestions based on a defined measure of similarity with respect to a group of candidate content components. Given a query or an input, these systems identify content components from the group and suggest the identified content components for addition to the digital content. Conventional systems for suggesting similar content components generate suggestions that are so similar to the input that these suggestions often do not add any element of creativity or other improvement to the digital content. In order to overcome the limitations of conventional systems, techniques and systems are described for suggesting content components.

In one example, a computing device implements a design system to receive input data describing a feature of a content component to be included in a hypertext markup language (HTML) document. For example, the feature is a style feature, a content feature, a context feature, etc. In this

example, the HTML document is an incomplete template and the content component is added to the HTML document to complete the template.

The design system represents the feature of the content component as a document object model (DOM) element and determines a hash value for the DOM element using locality-sensitive hashing based on p-stable distributions. For example, the locality-sensitive hashing determines hash values for inputs such that similar inputs are mapped to a same output segment or hash bucket with a high probability. This also facilitates approximate nearest neighbor searching which is performable in sublinear time.

The design system uses the hash value to identify a particular hash bucket from content component data that describes hash buckets and hash values included in the hash buckets. For example, the hash values are determined and grouped into the hash buckets using the locality-sensitive hashing based on p-stable distributions for DOM elements extracted from a corpus of HTML documents. Because the locality-sensitive hashing is applied in this manner, hash values included in individual ones of the hash buckets correspond to extracted DOM elements which are similar to each other. Accordingly, hash values included in the particular hash bucket correspond to extracted DOM elements that are similar to each other and are also similar to the DOM element.

The design system computes Manhattan distances between the hash value and the hash values included in the particular hash bucket. In one example, the Manhattan distances reflect a similarity between the DOM element and the DOM elements extracted from the corpus of HTML documents that correspond to the hash values included in the particular hash bucket. The design system generates indications of candidate content components for display in a user interface based on the Manhattan distances. For example, the candidate content components are selectable for inclusion in the HTML document. In this manner the template is completable using suggested content components that are similar to an input or query and also improve the HTML document such as by improving a visual appearance of the document.

By representing the content components extracted from the corpus of HTML documents as DOM elements to generate the content component data and by representing queries of the content component data as DOM elements, the described systems define similarity using a variety of style, content, and context features. This enables the described systems to suggest content components for creating and/or editing digital content that are similar to an input/query but which also improve the digital content which is not possible in conventional systems that generate suggestions which lack creativity. Additionally, by using the locality-sensitive hashing based on p-stable distributions to generate and query the content component data, the described systems are capable of generating content component suggestions in substantially real time from a group of candidate content components which is much larger than is possible in conventional systems. This is because the locality-sensitive hashing facilitates approximate nearest neighbor searching which is performable in sublinear time.

Term Examples

As used herein, the term "content component" refers to any element which is includable in a hypertext markup language (HTML) document. Examples of content components include digital images, text, banners, buttons, tables, graphics, icons, and so forth.

As used herein, the term "feature" of a content component refers to a characteristic of the content component. Examples of features of a content component include style, context, content, etc.

As used herein, the term "style" of a content component refers to a visual characteristic of the content component. By way of example, italic is a style of text.

As used herein, the term "context" of a content component refers to a characteristic surrounding the content component. By way of example, a background object is a context of text.

As used herein, the term "content" of a content component refers to a characteristic that is contained in or expressed by the content component. By way of example, a meaning of glyphs rendered as text is a content of the text.

In the following discussion, an example environment is first described that employs examples of techniques described herein. Example procedures are also described which are performable in the example environment and other environments. Consequently, performance of the example procedures is not limited to the example environment and the example environment is not limited to performance of the example procedures.

Example Environment

FIG. **1** is an illustration of an environment **100** in an example implementation that is operable to employ digital systems and techniques as described herein. The illustrated environment **100** includes a computing device **102** connected to a network **104**. The computing device **102** is configurable as a desktop computer, a laptop computer, a mobile device (e.g., assuming a handheld configuration such as a tablet or mobile phone), and so forth. Thus, the computing device **102** is capable of ranging from a full resource device with substantial memory and processor resources (e.g., personal computers, game consoles) to a low-resource device with limited memory and/or processing resources (e.g., mobile devices). In some examples, the computing device **102** is representative of a plurality of different devices such as multiple servers utilized to perform operations "over the cloud."

The illustrated environment **100** also includes a display device **106** that is communicatively coupled to the computing device **102** via a wired or a wireless connection. A variety of device configurations are usable to implement the computing device **102** and/or the display device **106**. The computing device **102** includes a storage device **108** and design module **110**. The design module **110** is illustrated as having, receiving, and/or transmitting input data **112**.

The input data **112** describes input features **114**. In the illustrated example, the input features **114** include "inspiring image" which is a content feature in one example. For example, the input features **114** also include "1686×1125" which is a size feature. In one example, the size is a style feature. In another example, the size is a context feature.

The design module **110** receives the input data **112** and processes the input data **112** as well as content component data **116** to suggest content components. For example, the content component data **116** describes hash values for document object model (DOM) elements which are extracted from a corpus of hypertext markup language (HTML) documents. In one example, the design module **110** receives and/or accesses the content component data **116**. In another example, the design module **110** generates the content component data **116**.

For example, the content component data **116** is generated by extracting HTML elements from the corpus of HTML documents and representing the extracted HTML elements as DOM elements. Each of the DOM elements includes content features, context features, and/or style features. In this example, the hash values for the DOM elements are determined, e.g., using locality-sensitive hashing based on p-stable distributions. As a result, DOM element representations of the extracted HTML elements are grouped into hash buckets such that similar DOM element representations are grouped into a same hash bucket.

Because the content component data **116** is generated in this manner, hash values included in a hash bucket described by the content component data **116** correspond to DOM element representations having similar content features, context features, and/or style features. Once identified, these DOM element representations are usable to suggest corresponding extracted HTML elements as candidate content components. In order to suggest content components in one example, the design module **110** represents the input data **112** as a DOM element having the input features **114** and uses the locality-sensitive hashing based on p-stable distributions to compute a hash value for the DOM element.

For example, the hash value for the DOM element corresponds to a particular hash bucket described by the content component data **116**. Hash values included in the particular hash bucket correspond to DOM elements having content features, context features, and/or style features which are similar to the input features **114**. The design module **110** computes Manhattan distances between the hash value for the DOM element and the hash values included in the particular hash bucket.

The design module **110** suggests a candidate content component **118** based on the Manhattan distances and this candidate content component **118** is displayed in a user interface **120** of the display device **106**. In one example, the candidate content component **118** is an extracted HTML element from the corpus of HTML documents which corresponds to a hash value having a shortest Manhattan distance from the hash value for the DOM element in the particular hash bucket. As shown in FIG. **1**, the candidate content component **118** includes features which are similar to the input features **114** described by the input data **112**.

For example, the candidate content component **118** has a size equal to 1686×1125 which is identical to the size feature of the input features **114**. The candidate content component **118** is also an image depicting a person viewing a rugged landscape with a caption "Go Farther" which inspires a viewer of the image, e.g., to overcome adversity. Although illustrated as a single candidate content component **118**, it is to be appreciated that the design module **110** displays a list of candidate content components in some examples which are sorted based on the Manhattan distances. The list is sorted in ascending order of the Manhattan distances in an example in which the design module **110** arranges the candidate content components from most similar to the input features **114** to least similar to the input features **114**. The list is sorted in descending order of the Manhattan distances in another example in which the design module **110** arranges the candidate content components from least similar to the input features **114** to most similar to the input features **114**.

FIG. **2** depicts a system **200** in an example implementation showing operation of a design module **110**. The design module **110** is illustrated to include a document object model (DOM) module **202**, a hashing module **204**, a relevancy module **206**, and a display module **208**. The design module **110** is illustrated as receiving the input data **112** and the content component data **116**. In some examples, the design module **110** generates the content component data **116**.

FIG. **3** illustrates an example representation **300** of generating content component data **116**. The representation **300** includes hypertext markup language (HTML) documents **302-306** which include content components and the design module **110** extracts the content components from the HTML documents **302-306**. The design module **110** represents these extracted content components as a set **308** of document object model (DOM) elements. As shown, the set **308** includes DOM elements **310-332**. Each of the DOM elements **310-332** includes content features, context features, and/or style features.

For example, each of the DOM elements **310-332** includes features extracted from the HTML documents **302-306** such as tags (e.g., BUTTON, TD, TR, DIV, SPAN, and so forth), coordinates, e.g., top, left, right, bottom, and center coordinates. In one example, the center coordinates also include a percentile with respect to a corresponding one of the HTML documents **302-306**. In another example, the features of the DOM elements **310-332** include hierarchy information such as a number of ancestors, lists of direct ancestors, types of child tags, a number of descendants, siblings of a same tag, and so forth. In some examples, the features of the DOM elements **310-332** include information such as style attributes of a parent, foreground color values, background color values, indications whether a background is an image or not an image, font family information (e.g., size, weight, alignment, decoration, shadow, etc.), border width, margins and padding, dominant colors of surrounding pixels, etc.

For example, DOM elements **310-316** correspond to content components extracted from HTML document **302**, DOM elements **318-324** correspond to content components extracted from HTML document **304**, and DOM elements **326-332** correspond to content components extracted from HTML document **306**. For each of the DOM elements **310-332**, the design module **110** extracts its content features, context features, and/or style features and compiles these features into a matrix **334**.

In one example, the matrix **334** includes an identifier for each of the DOM elements **310-332** and the extracted content features, context features, and/or style features of a corresponding one of the DOM elements **310-332**. Based on the matrix **334**, the hashing module **204** computes hash values for the DOM elements **310-332** and uses the hash values to assign the DOM elements **310-332** to a set **336** of hash buckets **338-344**. For example, the hashing module **204** computes the hash values using locality-sensitive hashing based on p-stable distributions. By computing the hash values in this manner, the hashing module **204** maps (with a high probability) similar DOM elements **310-332** to a same one of the hash buckets **338-344**.

For example, DOM elements **312**, **320**, and **326** are included in hash bucket **338** which indicates that the DOM elements **312**, **320**, and **326** are similar to each other even though DOM element **312** was extracted from the HTML document **302**, DOM element **320** was extracted from the HTML document **304**, and DOM element **326** was extracted from the HTML document **306**. Similarly, DOM elements **318**, **324**, and **330** are included in hash bucket **340**; DOM elements **310**, **328**, and **332** are included in hash bucket **342**; and DOM elements **314**, **316**, and **322** are included in hash bucket **344**. Accordingly, DOM elements **318**, **324**, and **326** are similar to each other; DOM elements **310**, **328**, and **332** are similar to each other; and DOM elements **314**, **316**, and **322** are similar to each other. The design module **110**

generates the content component data **116** as describing the hash values and corresponding hash buckets **338-344** for the DOM elements **310-332**.

FIGS. **4**A, **4**B, **4**C, and **4**D illustrate an example of suggesting content components. FIG. **4**A illustrates a representation **400** of a hypertext markup language (HTML) document. FIG. **4**B illustrates a representation **402** of input features **114** described by the input data **112**. FIG. **4**C illustrates a representation **404** of identifying a hash bucket based on the input data **112**. FIG. **4**D. illustrates a representation **406** of identified candidate content components based on the identified hash bucket.

As shown in FIG. **4**A, the HTML document is an e-mail template and includes content components **408-416**. For example, content component **408** is text which includes content of "Pete's Pools and Accessories." Content component **410** is an icon depicting a person swimming and content component **412** is a button that indicates "Click for Special Offer." Content components **414** and **416** are digital images. For example, the content component **414** depicts a swimming pool and the content component **416** depicts a person swimming in a swimming pool.

The HTML document also includes an incomplete portion **418** and this incomplete portion **418** is usable to query the content component data **116** to identify content components which are usable to complete the incomplete portion **418**. The design module **110** receives this query as input data **112**. In one example, a user interacts with an input device and specifies at least one feature of a content component to generate the input data **112** and query the content component data **116**. In another example, the input data **112** is generated automatically, e.g., based on features of the content components **408-416** included in the HTML document.

With reference to FIG. **2**, the DOM module **202** receives the input data **112** that describes features of a content component and the DOM module **202** processes the input data **112** to represent the input data **112** as a DOM element having the features of the content component. For example, the DOM module **202** generates DOM data **210** describing the DOM element representation having the features of the content component. As shown, the hashing module **204** receives the DOM data **210** and processes the DOM data to generate hash value data **212**.

The representation **402** illustrated in FIG. **4**B includes an example **420** of the DOM data **210**. The example **420** includes feature groups and corresponding features such as tag information, parent's CSS, ancestors, children tags, siblings, dominant colors of surrounding pixels, and so forth. The hashing module **204** receives the DOM data **210** and computes a hash value **422** for the DOM element representation described by the DOM data **210** using the locality-sensitive hashing based on p-stable distributions. For example, the hashing module **204** computes the hash value **422** using the same locality-sensitive hashing based on p-stable distributions that was used to generate the content component data **116**. The hashing module **204** generates the hash value data **212** as describing the hash value **422**.

The relevancy module **206** receives the hash value data **212** and the content component data **116** and processes the hash value data **212** and/or the content component data **116** to generate candidate data **214**. As illustrated in FIG. **4**C, the relevancy module **206** maps the hash value **422** to a particular one of the hash buckets **338-344** described by the content component data **116**. In order to identify the particular hash bucket, the relevancy module **206** performs an approximated nearest neighbor search of the content component data **116** using the hash value **422** as a query. In this example, the hash value **422** is included in the hash bucket **342** which also includes the DOM elements **310**, **328**, **332**, etc. The relevancy module **206** computes Manhattan distances between the hash value **422** and hash values corresponding to each of the DOM elements included in the hash bucket **342**. For example, the relevancy module **206** generates candidate data **214** as describing the Manhattan distances and corresponding DOM elements.

The display module **208** receives the candidate data **214** and processes the candidate data **214** to generate indications of candidate content components **424-434** which are illustrated in FIG. **4**D. For example, the display module **208** displays the candidate content components **424-434** based on the Manhattan distances in an ascending order. In this example, candidate content component **424** corresponds to a DOM element included in the hash bucket **342** which has a shortest Manhattan distance from the hash value **422**. Similarly, candidate content component **434** corresponds to a DOM element included in the hash bucket **342** which has a longest Manhattan distance from the hash value **422**.

Accordingly, candidate content component **426** is associated with a greater Manhattan distance than the candidate content component **424**. Candidate content component **428** is associated with a greater Manhattan distance than the candidate content component **426**. Candidate content component **430** is associated with a greater Manhattan distance than the candidate content component **428**, and candidate content component **432** is associated with a greater Manhattan distance than the candidate content component **430**.

Any of the candidate content components **424-434** are usable to complete the incomplete portion **418** of the HTML document. For example, the candidate content component **424** is a graphic depicting a person swimming. The candidate content component **426** is an icon depicting a lifeguard and the candidate content component **428** is a graphic depicting a character in a body of water. As shown, the candidate content component **430** is a button indicating "World's Best Pool!" and the candidate content component **432** is a digital image depicting a person swimming in a pool. Finally, the candidate content component **434** is graphic art advocating that one should "swim for health in safe and pure pools."

In general, functionality, features, and concepts described in relation to the examples above and below are employed in the context of the example procedures described in this section. Further, functionality, features, and concepts described in relation to different figures and examples in this document are interchangeable among one another and are not limited to implementation in the context of a particular figure or procedure. Moreover, blocks associated with different representative procedures and corresponding figures herein are applicable individually, together, and/or combined in different ways. Thus, individual functionality, features, and concepts described in relation to different example environments, devices, components, figures, and procedures herein are usable in any suitable combinations and are not limited to the particular combinations represented by the enumerated examples in this description.

Example Procedures

The following discussion describes techniques which are implementable utilizing the previously described systems and devices. Aspects of each of the procedures are implementable in hardware, firmware, software, or a combination thereof. The procedures are shown as a set of blocks that specify operations performed by one or more devices and are not necessarily limited to the orders shown for performing the operations by the respective blocks. In portions of the

following discussion, reference is made to FIGS. **1-4**. FIG. **5** is a flow diagram depicting a procedure **500** in an example implementation in which input data describing a feature of a content component to be included in a hypertext markup language (HTML) document is received and indications of candidate content components are generated for inclusion in the HTML document.

Input data describing a feature of a content component to be included in an HTML document is received (block **502**). The computing device **102** implements the design module **110** to receive the input data in one example. The feature of the content component is represented as a document object model (DOM) element (block **504**). For example, the design module **110** represents the feature of the content component as the DOM element. A hash value for the DOM element is determined using locality-sensitive hashing (block **506**). The design module **110** determines the hash value using the locality-sensitive hashing in one example.

Manhattan distances are computed (block **508**) between the hash value and hash values described by a segment of content component data, the hash values determined using the locality-sensitive hashing for DOM elements extracted from a corpus of HTML documents. The computing device **102** implements the design module **110** to compute the Manhattan distances in an example. Indications of candidate content components are generated for inclusion in the HTML document based on the Manhattan distances (block **510**), the indications are generated for display in a user interface. For example, the design module **110** generates the indications of the candidate content components for display in the user interface.

FIG. **6** illustrates an example representation **600** of a user interface for suggesting content components. As shown, the representation **600** includes a hypertext markup language (HTML) document **602** and a user interface element **604**. The HTML document **602** is template such as an e-mail template in this example and includes a first content component **606**, a second content component **608**, and a content component input field **610**. In one example, the HTML document **602** is an incomplete version of a template and the corpus of HTML documents used to generate the content component data **116** includes completed versions of the template. As shown, the first content component **606** is a bar graph which includes values for every month of a calendar year and the second content component **608** is a digital image depicting results of an example analytics query.

The content component input field **610** is an incomplete portion of the HTML document **602** and a user interacts with an input device to provide a user input which the design module **110** receives as the input data **112**. Responsive to receiving the input data **112**, the design module **110** displays indications of candidate content components which are selectable for inclusion in the content component input field **610** to complete the incomplete portion of the HTML document **602**. For example, the input device is a mouse, keyboard, microphone, stylus, and so forth. In the illustrated example, the input device is a microphone or a keyboard and the user interacts with the input device to indicate "I would like to add similar content" which is displayed in a user input field **612** of the user interface element **604**.

The design module **110** receives the indicated user input as the input data **112** and extracts the first content component **606** and the second content component **608** from the HTML document **602**. For example, the design module **110** represents the first content component **606** and the second content component **608** as document object model (DOM) elements having style features, context features, and/or content features. The design module **110** determines a hash value for the DOM elements using locality-sensitive hashing based on p-stable distributions.

In one example, the design module **110** accesses the content component data **116** which was generated using the locality-sensitive hashing based on p-stable distributions and identifies a hash bucket described by the content component data **116** that corresponds to the hash value. The hash bucket includes additional hash values which were determined for DOM element representations of content components extracted from a corpus of HTML documents using the locality-sensitive hashing based on p-stable distributions. The design module **110** computes Manhattan distances between the hash value and the additional hash values and generates indications of candidate content components **614-618** based on the Manhattan distances.

For example, candidate content component **614** is associated with an additional hash value included in the hash bucket that has a shortest Manhattan distance from the hash value. As shown, the candidate content component **614** is displayed in a as a suggestion to add a line chart in a field of the user interface element **604**. In some examples, the design module **110** adds the candidate content component **614** to the HTML document **602** automatically and without user intervention.

Candidate content component **616** is associated with an additional hash valued included in the hash bucket which has a second shortest Manhattan distance from the hash value. The candidate content component **616** is displayed as a suggestion to add a bar chart in the field of the user interface element **604**. In an example in which the HTML document **602** in an incomplete version of a template, the design module **110** generates a complete version of the template by adding the candidate content component **614** to the HTML document **602** and the design module **110** generates an additional completed version of the template by adding the candidate content component **616** to the HTML document **602**. For example, the design module **110** generates the additional completed version of the template automatically and without user intervention.

In an example, candidate content component **618** is associated with an additional hash value included in the hash bucket that has a third shortest Manhattan distance from the hash value. As illustrated, the candidate content component **618** is displayed as a suggestion to add a metric icon in the field of the user interface element **604**. In one example, the user interacts with the input device and selects one of the candidate content components **614-618** for inclusion in the HTML document **602**. In this example, the design module **110** automatically adds the selected candidate content component to the HTML document **602** by rendering the selected candidate content component in the content component input field **610** which completes the incomplete portion of the HTML document **602**.

In the illustrated example, the design module **110** also computes and displays consistency scores **620-624** for each of the candidate content components **614-618**. The consistency scores **620-624** represent a number of style features, context features, and/or content features that are included in DOM element representations of each of the candidate content components **614-618** and which are also included in the DOM element representation of the first content component **606** and the second content component **608**. In one example, the consistency scores **620-624** are not weighted meaning that no particular feature is considered more important than any other feature. In this example, the design module **110** represents the style features, context features,

and/or content features that are included in DOM element representations as vectors using one-hot encoding and computes the consistency scores **620-624** as dot products of the vectors. In another example, the consistency scores **620-624** are weighted. In this example, a particular feature such as a size feature is assigned a greater weight than another feature such as a siblings feature.

As shown, the candidate content component **614** has a consistency score **620** equal to 24, the candidate content component **616** has a consistency score **622** equal to 23, and the candidate component **618** has a consistency score **624** equal to 19. In an example in which the user desires to complete the HTML document **602** using a candidate content component having a highest similarity to the first and second content components **606**, **608**, then the user selects the candidate content component **614** to include in the content component input field **610**. In an example in which the user desires to complete the HTML document **602** using a candidate content component having a lowest similarity to the first and second content components **606**, **608**, then the user selects the content component **618** to include in the content component input field **610**. Accordingly, the consistency scores **620-624** are leverageable to increase or decrease an amount of variation between content components included in the HTML document **602**.

In another example, instead of selecting one of the candidate content components **614-618** for inclusion in the content component input field **610**, the user desires to map a style of one of the content components **614-618** to a different content component which the user has included in the content component input field **610**. In this example, the user interacts with the input device and selects the content component **618** to transfer a style of the content component **618** to the different content component. To do so, the design module **110** represents the content component **618** and the different content component as trees with nodes corresponding to the features included in the DOM element representation of the content component **618** and included in a DOM element representation of the different content component. The nodes of the trees are connected by edges which reflect a cost or a difference between two nodes connected by each edge. The design module **110** determines an optimized set of edges which minimizes the corresponding costs or differences and transfers style features from the content component **618** to the different content component along the optimized set of edges.

FIG. **7** is a flow diagram depicting a procedure **700** in an example implementation in which input data describing a feature of a content component to be included in a hypertext markup language (HTML) document is received and indications of particular candidate content components are generated for inclusion in the HTML document. Input data describing a feature of a content component to be included in an HTML document is received (block **702**). For example, the computing device **102** implements the design module **110** to receive the input data. The feature of the content component is represented as a document object model (DOM) element (block **704**). In one example, the design module **110** represents the feature of the content component as the DOM element. A hash value for the DOM element is determined using locality-sensitive hashing (block **706**). The design module **110** determines the hash value using the locality-sensitive hashing in one example.

Content component data is accessed (block **708**) that describes hash buckets and candidate content components assigned to the hash buckets using the locality-sensitive hashing, the candidate content components extracted from a corpus of HTML documents. In an example, the computing device **102** implements the design module **110** to access the content component data. A particular hash bucket is identified (block **710**) from the content component data based on the hash value. The design module **110** identifies the particular hash bucket from the content component data in one example. Indications of particular candidate content components that are included in the particular hash bucket are generated for inclusion in the HTML document (block **712**), the indications are generated for display in a user interface. For example, the design module **110** generates the indications of the particular candidate content components.

Example System and Device

FIG. **8** illustrates an example system **800** that includes an example computing device that is representative of one or more computing systems and/or devices that are usable to implement the various techniques described herein. This is illustrated through inclusion of the design module **110**. The computing device **802** includes, for example, a server of a service provider, a device associated with a client (e.g., a client device), an on-chip system, and/or any other suitable computing device or computing system.

The example computing device **802** as illustrated includes a processing system **804**, one or more computer-readable media **806**, and one or more I/O interfaces **808** that are communicatively coupled, one to another. Although not shown, the computing device **802** further includes a system bus or other data and command transfer system that couples the various components, one to another. For example, a system bus includes any one or combination of different bus structures, such as a memory bus or memory controller, a peripheral bus, a universal serial bus, and/or a processor or local bus that utilizes any of a variety of bus architectures. A variety of other examples are also contemplated, such as control and data lines.

The processing system **804** is representative of functionality to perform one or more operations using hardware. Accordingly, the processing system **804** is illustrated as including hardware elements **810** that are configured as processors, functional blocks, and so forth. This includes example implementations in hardware as an application specific integrated circuit or other logic device formed using one or more semiconductors. The hardware elements **810** are not limited by the materials from which they are formed or the processing mechanisms employed therein. For example, processors are comprised of semiconductor(s) and/or transistors (e.g., electronic integrated circuits (ICs)). In such a context, processor-executable instructions are, for example, electronically-executable instructions.

The computer-readable media **806** is illustrated as including memory/storage **812**. The memory/storage **812** represents memory/storage capacity associated with one or more computer-readable media. In one example, the memory/storage **812** includes volatile media (such as random access memory (RAM)) and/or nonvolatile media (such as read only memory (ROM), Flash memory, optical disks, magnetic disks, and so forth). In another example, the memory/storage **812** includes fixed media (e.g., RAM, ROM, a fixed hard drive, and so on) as well as removable media (e.g., Flash memory, a removable hard drive, an optical disc, and so forth). The computer-readable media **806** is configurable in a variety of other ways as further described below.

Input/output interface(s) **808** are representative of functionality to allow a user to enter commands and information to computing device **802**, and also allow information to be presented to the user and/or other components or devices using various input/output devices. Examples of input

devices include a keyboard, a cursor control device (e.g., a mouse), a microphone, a scanner, touch functionality (e.g., capacitive or other sensors that are configured to detect physical touch), a camera (e.g., which employs visible or non-visible wavelengths such as infrared frequencies to recognize movement as gestures that do not involve touch), and so forth. Examples of output devices include a display device (e.g., a monitor or projector), speakers, a printer, a network card, tactile-response device, and so forth. Thus, the computing device **802** is configurable in a variety of ways as further described below to support user interaction.

Various techniques are described herein in the general context of software, hardware elements, or program modules. Generally, such modules include routines, programs, objects, elements, components, data structures, and so forth that perform particular tasks or implement particular abstract data types. The terms "module," "functionality," and "component" as used herein generally represent software, firmware, hardware, or a combination thereof. The features of the techniques described herein are platform-independent, meaning that the techniques are implementable on a variety of commercial computing platforms having a variety of processors.

Implementations of the described modules and techniques are storable on or transmitted across some form of computer-readable media. For example, the computer-readable media includes a variety of media that is accessible to the computing device **802**. By way of example, and not limitation, computer-readable media includes "computer-readable storage media" and "computer-readable signal media."

"Computer-readable storage media" refers to media and/or devices that enable persistent and/or non-transitory storage of information in contrast to mere signal transmission, carrier waves, or signals per se. Thus, computer-readable storage media refers to non-signal bearing media. The computer-readable storage media includes hardware such as volatile and non-volatile, removable and non-removable media and/or storage devices implemented in a method or technology suitable for storage of information such as computer readable instructions, data structures, program modules, logic elements/circuits, or other data. Examples of computer-readable storage media include, but are not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical storage, hard disks, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or other storage device, tangible media, or article of manufacture suitable to store the desired information and which are accessible to a computer.

"Computer-readable signal media" refers to a signal-bearing medium that is configured to transmit instructions to the hardware of the computing device **802**, such as via a network. Signal media typically embodies computer readable instructions, data structures, program modules, or other data in a modulated data signal, such as carrier waves, data signals, or other transport mechanism. Signal media also include any information delivery media. The term "modulated data signal" means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media include wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared, and other wireless media.

As previously described, hardware elements **810** and computer-readable media **806** are representative of modules, programmable device logic and/or fixed device logic implemented in a hardware form that is employable in some embodiments to implement at least some aspects of the techniques described herein, such as to perform one or more instructions. Hardware includes components of an integrated circuit or on-chip system, an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA), a complex programmable logic device (CPLD), and other implementations in silicon or other hardware. In this context, hardware operates as a processing device that performs program tasks defined by instructions and/or logic embodied by the hardware as well as a hardware utilized to store instructions for execution, e.g., the computer-readable storage media described previously.

Combinations of the foregoing are also employable to implement various techniques described herein. Accordingly, software, hardware, or executable modules are implementable as one or more instructions and/or logic embodied on some form of computer-readable storage media and/or by one or more hardware elements **810**. For example, the computing device **802** is configured to implement particular instructions and/or functions corresponding to the software and/or hardware modules. Accordingly, implementation of a module that is executable by the computing device **802** as software is achieved at least partially in hardware, e.g., through use of computer-readable storage media and/or hardware elements **810** of the processing system **804**. The instructions and/or functions are executable/operable by one or more articles of manufacture (for example, one or more computing devices **802** and/or processing systems **804**) to implement techniques, modules, and examples described herein.

The techniques described herein are supportable by various configurations of the computing device **802** and are not limited to the specific examples of the techniques described herein. This functionality is also implementable entirely or partially through use of a distributed system, such as over a "cloud" **814** as described below.

The cloud **814** includes and/or is representative of a platform **816** for resources **818**. The platform **816** abstracts underlying functionality of hardware (e.g., servers) and software resources of the cloud **814**. For example, the resources **818** include applications and/or data that are utilized while computer processing is executed on servers that are remote from the computing device **802**. In some examples, the resources **818** also include services provided over the Internet and/or through a subscriber network, such as a cellular or Wi-Fi network.

The platform **816** abstracts the resources **818** and functions to connect the computing device **802** with other computing devices. In some examples, the platform **816** also serves to abstract scaling of resources to provide a corresponding level of scale to encountered demand for the resources that are implemented via the platform. Accordingly, in an interconnected device embodiment, implementation of functionality described herein is distributable throughout the system **800**. For example, the functionality is implementable in part on the computing device **802** as well as via the platform **816** that abstracts the functionality of the cloud **814**.

CONCLUSION

Although implementations of systems for suggesting content components have been described in language specific to structural features and/or methods, it is to be understood that the appended claims are not necessarily limited to the specific features or methods described. Rather, the specific

features and methods are disclosed as example implementations of systems for suggesting content components, and other equivalent features and methods are intended to be within the scope of the appended claims. Further, various different examples are described and it is to be appreciated that each described example is implementable independently or in connection with one or more other described examples.

What is claimed is:

1. In a digital medium environment, a method implemented by a computing device, the method comprising:

extracting, by a document object model (DOM) module, a content component included in a hypertext markup language (HTML) document;

representing, by the DOM module, a feature of the content component as a DOM element;

determining, by a hashing module, a hash value for the DOM element using locality-sensitive hashing;

accessing, by a relevancy module, content component data that describes hash buckets and candidate content components assigned to the hash buckets using the locality-sensitive hashing, the candidate content components extracted from a corpus of HTML documents; and

generating, by a display module for display in a user interface, an indication of a particular candidate content component for inclusion in the HTML document based on a Manhattan distance between the hash value for the DOM element and a particular hash value determined for the particular candidate content component.

2. The method as described in claim **1**, further comprising adding, automatically and without user intervention, the particular candidate content component to the HTML document.

3. The method as described in claim **1**, further comprising generating a consistency score for the particular candidate content component that represents a number of features included in a DOM element representation of the particular candidate content component that are also included in the DOM element.

4. The method as described in claim **3**, wherein the features are weighted.

5. The method as described in claim **3**, wherein the features are not weighted.

6. The method as described in claim **1**, wherein the feature of the content component is at least one of style, context, or content.

7. The method as described in claim **1**, further comprising transferring a style of the particular candidate content component to an additional content component included in the HTML document.

8. The method as described in claim **7**, further comprising representing the particular candidate content component as a tree with nodes corresponding to features included in a DOM element representation of the particular candidate content component.

9. The method as described in claim **1**, wherein the locality-sensitive hashing is based on p-stable distributions.

10. The method as described in claim **1**, wherein the HTML document is an incomplete version of a template and the corpus of HTML documents includes a completed version of the template.

11. In a digital medium environment, a system comprising:

a document object model (DOM) module implemented at least partially in hardware of a computing device to:

extract a content component included in a hypertext markup language (HTML) document; and

represent a feature of the content component as a DOM element;

a hashing module implemented at least partially in the hardware of the computing device to determine a hash value for the DOM element using locality-sensitive hashing;

a relevancy module implemented at least partially in the hardware of the computing device to compute Manhattan distances between the hash value and hash values described by content component data, the hash values determined using the locality-sensitive hashing for DOM elements extracted from a corpus of HTML documents; and

a display module implemented at least partially in the hardware of the computing device to generate, for display in a user interface, indications of candidate content components for inclusion in the HTML document based on the Manhattan distances.

12. The system as described in claim **11**, wherein the indications of the candidate content components include consistency scores that represent a number of features included in the DOM element that are also included in DOM element representations of the candidate content components.

13. The system as described in claim **11**, wherein the indications of the candidate content components are generated as a list arranged in an ascending order of the Manhattan distances.

14. The system as described in claim **11**, wherein the indications of the candidate content components are generated as a list arranged in a descending order of the Manhattan distances.

15. The system as described in claim **11**, wherein the feature of the content component is at least one of style, context, or content.

16. A system comprising:

means for extracting a content component included in a hypertext markup language (HTML) document;

means for representing a feature of the content component as a document object model (DOM) element;

means for determining a hash value for the DOM element using locality-sensitive hashing;

means for accessing content component data that describes hash buckets and candidate content components assigned to the hash buckets using the locality-sensitive hashing; and

means for generating, for display in a user interface, an indication of a particular candidate content component for inclusion in the HTML document based on a Manhattan distance between the hash value for the DOM element and a particular hash value determined for the particular candidate content component.

17. The system as described in claim **16**, further comprising means for generating a consistency score for the particular candidate content component.

18. The system as described in claim **16**, further comprising means for transferring a style of the particular candidate content component to an additional content component included in the HTML document.

19. The system as described in claim **16**, further comprising means for adding, automatically and without user intervention, the particular candidate content component to the HTML document.

20. The system as described in claim **16**, wherein the feature of the content component is at least one of style, context, or content.

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