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Enhanced Whiteboard Capture for Chat

Meetings are often held in meeting rooms that contain a physical whiteboard but no digital whiteboard or other such collaborative diagramming device. Meeting participants may use the physical whiteboard to sketch out diagrams during a discussion, such as sequence diagrams, block diagrams, org charts, roadmaps / timelines, graphs, charts, etc. In order to capture the content of a whiteboard for future reference and subsequent discussion or sharing in a chat service, a meeting participant may use a mobile device to capture an image of the whiteboard and then upload the image to a chat in the chat service.

There can be several problems when whiteboard images are captured and uploaded to chats in this way. For example, the image quality of the captured whiteboard images may be poor, since the lighting inside the meeting room may not be favorable, or there may be spots of bright glare or reflections on some parts of the whiteboard. Also, depending on where the meeting participant who captures the image is sitting or standing, the whiteboard image may be zoomed out / small, or skew and distorted due to perspective. Furthermore, upon capturing a whiteboard image with a camera on their mobile device, it might be hard for the user to find a suitable chat team to upload the whiteboard image, since a chat team associated with their meeting may not be automatically suggested to them or selected for them by default by the chat application.

Furthermore, an uploaded whiteboard image may be crudely drawn and unprofessional in appearance and may not be suitable for sharing with a wider audience beyond the original meeting participants. Also, the uploaded whiteboard image may contain shorthand codes or other kinds of references to proprietary information or elements that may not be understood by all others who may later view the uploaded image. Finally, the uploaded whiteboard image may not be easily searchable later, since the chat service may not understand the topic to which the whiteboard image relates or have any tags or other data characterizing the context or content of the image that can be used for populating an index used by a search feature of the chat service.

To solve these problem, a system may provide a mechanism for chat and collaboration services, whereby:

- 1) The system may allow a user of a chat or collaboration service to activate a specialized flow for uploading a whiteboard image, which uploaded image may then be subject to further processes of the system pertaining to whiteboard images.
- 2) The system may allow a user to tag or otherwise indicate images uploaded to a chat or collaboration service as being whiteboard images, subsequent to those images having been uploaded, which images may then be subject to further processes of the system pertaining to whiteboard images.
- 3) The system may automatically detect an image as being a whiteboard image, upon uploading of the image to a chat or collaboration service, or subsequent to uploading of the image to the chat or collaboration service, employing techniques of computer vision, AI+ML, and the like, which images may then be subject to further processes of the system pertaining to whiteboard images.
- 4) The system may perform processes upon whiteboard images to enhance them, such as by:
 - a) removing glare or reflections, b) straightening, strengthening, darkening, or otherwise

- repairing lines or generally improving their legibility, c) removing irrelevant or sensitive content adjacent to the primary content of the whiteboard image and captured inadvertently along with the primary content, and so on.
- 5) The system may further analyze and parse the content of uploaded whiteboard images, in order to determine semantic information and produce metadata and other data characterizing the content of the image for consumption by subsequent analysis, indexing, search, and other processes.
 - 6) The system may determine the identity of a specific whiteboard from which a whiteboard image was captured, along with the identity of a meeting room, conference room, or other venue containing the specific whiteboard, along with locational coordinates or other locational data associated with the whiteboard.
 - 7) The system may, utilizing semantic information, metadata, and other data characterizing the content of whiteboard images, perform processes upon whiteboard images to augment them, such as by: a) adding interactive links to definitions within a glossary for acronyms or other terms contained within images, b) adding interactive links to related documents or other related whiteboard images, c) expanding shorthand codes for elements or components or replacing such shorthand representations with more complete representations, and so on.
 - 8) The system may, utilizing a structured representation of the content of a whiteboard image and the elements contained therein, that is produced during parsing of the whiteboard image, along with semantic information, metadata, and other data characterizing the content of the whiteboard image, re-render a whiteboard image to produce a more professional and polished representation of its original content.
 - 9) The system may assess a whiteboard image, by analyzing the semantic information, metadata, and other data characterizing the content of the whiteboard image that is produced during parsing of the whiteboard image, in order to determine whether a whiteboard containing the image should be erased because of a risk of the content of the whiteboard image revealing confidential or sensitive information, were the content to be left on the associated whiteboard for an extended period of time, and the system may consequently recommend erasure of a whiteboard in such cases.
 - 10) The system may analyze a whiteboard image, as part of or subsequent to parsing of the whiteboard image, in order to determine the identities of one or more authors to whom the whiteboard image may be attributed.

The system of the disclosure comprises numerous aspects, as described below.

Whiteboard Image Detection Module

An aspect of the system is a whiteboard image detection module, which module is responsible for detecting if an uploaded image is of a whiteboard or substantially contains a whiteboard.

In order to detect a whiteboard in an image, the module may employ various means, including but not limited to: 1) using Machine Learning technologies, where data for training a model using supervised learning may include a variety of general images where a whiteboard is indicated as being present and a variety of images where a whiteboard is indicated as not being present, 2) using Machine Learning technologies, where a location-specific model is trained for

each meeting or conference room venue, and where data for training each location-specific model using supervised learning may include a variety of images taken at the location where a whiteboard is indicated as being present, such as whiteboard images taken at the location and uploaded by users of a chat service incorporating the system, 3) detecting the locational coordinates at which an image was captured and determining that the coordinates correspond to a meeting or conference room venue containing a whiteboard, thus increasing the chances of the captured image containing a whiteboard, 4) detecting the time at which an image was captured and determining that the time falls within a window of time corresponding to a meeting held at a meeting or conference room venue containing a whiteboard, thus increasing the chances of the captured image containing a whiteboard, 5) analyzing the content of one or more messages posted to a chat team to which an image is uploaded, which messages may be posted soon before or soon after posting of the image, and the content of which messages may indicate the nature of the uploaded image being of or containing a whiteboard, such as in the example message “Here is the architecture we sketched out on the whiteboard”, 6) accepting input by a user positively indicating an image to be of or containing a whiteboard, such as when a user activates a feature of the chat software to specifically upload a whiteboard image, or using a facility in the user interface of the chat software to flag an uploaded image as being or containing a whiteboard, such as during the initial process of uploading an image or subsequently when reviewing images uploaded in the past.

It should be appreciated that an embodiment of the system may employ any one of or any combination of the aforementioned or other detection methods, and it should further be appreciated that certain of the methods may detect a whiteboard image with greater confidence, and that certain of the methods may detect a whiteboard image with lesser confidence, and that certain of the methods may serve purely to strengthen or weaken an overall confidence in detection of a whiteboard image by the system and where primary detection may be the responsibility of other of the methods.

Activation of Whiteboard Image Detection Module

In a typical embodiment, activation of the whiteboard image detection module may occur according to any of numerous supported methods.

In one case, the module may be activated at the time of a user capturing an image using a camera application on their mobile device, which camera application may incorporate the Whiteboard Image Detection Module, and which camera application may invoke the module to perform detection for the image being captured. Alternatively, the module may be activated by an explicit action of the user at the time of the user capturing an image using a camera application on their mobile device, such as by the user choosing a dedicated option provided in the camera application for capturing pictures of whiteboards.

In another case, the module may be activated at the time of a user uploading an image to a chat using a client application of the chat service, which client application may incorporate the Whiteboard Image Detection Module, and which client application may invoke the module to perform detection for the image being uploaded to a chat. Alternatively, the module may be activated by an explicit action of the user at the time of the user uploading an image to a chat

using the client application of the chat service, such as by the user choosing a dedicated option provided in the client application for uploading pictures of whiteboards.

In yet another case, the module may be activated as part of an audit process that is initiated to assess images that have historically been uploaded to chat conversations and were not previously analyzed by the module, to determine if they contain whiteboard content. Such an audit process may be initiated automatically by the system, upon the features of the system being enabled for the first time for a chat account in which historical communications already exist, or upon historical communications being imported into a chat account from other sources, such as when an account is migrated from another chat service.

In yet another case, the module may be activated automatically only when a user views an already uploaded image that was not previously analyzed by the module. Alternatively, the module may be activated explicitly by the user, by way of a dedicated control in the user interface of the chat software that allows the user to indicate that an uploaded image is of a whiteboard.

Whiteboard Image Enhancement Module

An aspect of the system is a whiteboard image enhancement module, which module is responsible for performing one or more image enhancements specifically designed to improve the quality and legibility of whiteboard images, including but not limited to: 1) detecting of the boundaries of a whiteboard drawing, as distinct from detecting the physical edges of the whiteboard, itself, 2) zooming and correction of perspective of a cropped whiteboard drawing, 3) removal of extraneous content, such as remnants of content not related to the cropped whiteboard drawing but that intruded into the area of the whiteboard drawing, 4) removal of faint remnant markings from previously erased whiteboard drawings, 5) sharpening of lines and edges within the cropped whiteboard drawing, in order to make text and drawing lines clearer, 6) auto-leveling of colors, normalization, white balancing, etc. 7) removal of reflections and glare.

Whiteboard Location Determiner Module

An aspect of the system is a whiteboard location determiner module, which module is responsible for determining a physical location of a whiteboard featured in a whiteboard image, which determination may employ various strategies, including but not limited to: 1) using locational coordinates provided from a device with which a whiteboard image was captured and recorded at the time of capturing the whiteboard image, 2) using AI+ML to identify a specific whiteboard – and, thereby, its associated physical location – by computer vision analysis of a whiteboard image, where training data could be supplied by an admin, IT staff, or facilities personnel, or could be learned from some amount of physical location tagging by users of uploaded whiteboard images until the system becomes able to recognize a whiteboard from its appearance, 3) using meeting venue information obtained from a scheduling or calendaring system that indicates the physical location of a meeting during which a whiteboard image was captured, 4) allowing users to explicitly tag the location of a whiteboard featured in an uploaded whiteboard image.

Whiteboard Image Parsing Module

An aspect of the system is a whiteboard image parsing module, which module is responsible for parsing whiteboard images in order to produce a structured data representation of the content of whiteboard images, which structured data representation may be used for multiple subsequent processes, such as: 1) determination of the authorship of a whiteboard image, 2) generation of tags and other descriptors to facilitate indexing and searching for whiteboard images uploaded to a chat service, 3) augmentation of a whiteboard image with additional elements such as definitions, labels, text annotations, links, etc., 4) re-rendering of all or parts of a whiteboard image to produce clearer or more professional results, 5) determining whether to recommend prompt erasure of a whiteboard, based upon it containing content deemed sensitive in nature.

The process of parsing the content of a whiteboard may comprise numerous sub-processes, including but not limited to: 1) detection of labels / text, and parsing / transcribing thereof using OCR technologies, 2) detection of shapes, arrows, etc. and translation thereof to equivalent data representations in diagramming languages such as UML, 3) detection of lines and their associated qualities, such as line weight, line color, arrow presence and associated styles thereof, line style (e.g. solid, dotted, dashed, broken, etc.), and translation thereof to equivalent data representations in diagramming languages such as UML, 4) detection of proprietary symbols or shorthand representations pertaining to the organization, or an industry in which the organization operates, 5) detection of signatures or other forms of author attributions for the whiteboard content, 6) handwriting analysis of labels or other text, to assist in identifying authorship for the whiteboard content.

Whiteboard Image Authorship Attribution Module

An aspect of the system is a whiteboard image authorship attribution module, which module is responsible for determining one or more authors to whom creation of a whiteboard image may be attributed, which determination may employ various strategies, including but not limited to: 1) identifying authors by their unique handwriting, as evidenced in labels, descriptions, or other written portions of whiteboard images, using AI+ML technologies, and using examples of the handwriting of various users as training data, 2) identifying authors by their unique drawing style and associated characteristics, such as types of shapes typically used, how shapes are drawn, line stroke characteristics, hand-steadiness, level of detail, etc., using AI+ML technologies, and using previous examples of whiteboard drawings by various users as training data, 3) identifying authors by word choices, language style, subject matter, or other aspects of the content of whiteboard images, using AI+ML technologies, and using previous examples of drawings (drawn on whiteboards or created digitally) by various users as training data, 4) identifying authors by detection of signatures or initials of authors written alongside whiteboard drawings, 5) observation of an individual performing the act of drawing a whiteboard image, as captured in a video stream of a conferencing system operating in the physical venue featuring the whiteboard, and as identified using AI+ML technologies such as facial recognition software, 6) prompting the user capturing or uploading a whiteboard image to confirm that they are the author of the image, or allowing this user to specify or select one or more other users as authors of the whiteboard image.

Whiteboard Image Tagging Module

An aspect of the system is a whiteboard image tagging module, which module is responsible for generating one or more tags, keywords, or other types of classifiers for whiteboard images, which classifiers may relate to a whiteboard image in numerous ways, including but not limited to: 1) when the whiteboard image was captured (e.g. date / time), 2) where the whiteboard image was captured (e.g. office location, meeting or conference room, co-working facility, convention center), as determined by a separate Whiteboard Location Determiner Module, 3) by whom the whiteboard image was captured, 4) what device was used to capture the whiteboard image (e.g. camera make and model, mobile phone make and model), 5) a scheduled meeting during which the whiteboard image was captured, 6) one or more authors to whom creation of the whiteboard image may be attributed, as determined by a separate Whiteboard Image Authorship Attribution Module, 7) a diagram type of the whiteboard image (e.g. swim lanes / sequence diagram, flowchart, block diagram, org chart, UI wireframe, roadmap / timeline, etc.), as determined from data produced by the separate Whiteboard Image Parsing Module, 8) a topic or topics to which the diagram relates (e.g. system architecture, security, new product launch roadmap, new office building layout, etc.), as determined from data produced by the separate Whiteboard Image Parsing Module, 9) objects or elements referred to in whiteboard images, as determined from labels detected by the separate Whiteboard Image Parsing Module.

Among other applications, the tags, keywords, or other types of classifiers produced by the module upon analyzing whiteboard images may be used for creating search indexes for uploaded whiteboard images in order to facilitate searching for and filtering of the many whiteboard images uploaded to chats in a chat service, and such tags, keywords, or other classifiers may be listed in a user interface of a search function of the chat service for the user to select and incorporate into search queries or filters for filtering the results of search queries.

Whiteboard Image Augmentation Module

An aspect of the system is a whiteboard image augmentation module, which module is responsible for augmenting a whiteboard image with additional elements, and which augmentation process includes but is not limited to: 1) adding interactive links to definitions within a glossary, for acronyms or other terms contained within the whiteboard image, 2) adding interactive links to related documents or other related whiteboard images, 3) adding interactive links to profiles, contact information, or communication actions for one or more authors of a whiteboard image, 4) expanding shorthand codes for elements or components, contained within the whiteboard image, or replacing such shorthand representations with more complete representations as overlay elements.

In order to determine suitable elements with which a whiteboard image should be augmented, or suitable other augmentation processes that should be applied to a whiteboard image, the module may interpret the data produced by the separate Whiteboard Image Parsing Module, Whiteboard Image Authorship Attribution Module, Whiteboard Image Tagging Module, and any other modules of the system that may produce distilled data derived from and characterizing the whiteboard image.

Whiteboard Image Re-Rendering Module

An aspect of the system is a whiteboard image re-rendering module, which module is responsible for re-rendering all or parts of a whiteboard image to produce clearer or more professional results, and which re-rendering process may include such techniques as: 1) using idealized shape building blocks (e.g. blocks, circles, diamonds, data store symbols, UI buttons, etc.) to replace hand-drawn counterparts within the whiteboard image, 2) determining a diagram type of a whiteboard image (e.g. swim lanes / sequence diagram, flowchart, block diagram, org chart, UI wireframe, roadmap / timeline, etc.), parsing the content of the whiteboard image in accordance with the determined diagram type, and re-rendering the diagram type in an idealized form from the structured data representing the content of the whiteboard image, using the appropriate rendering engine for the diagram type, 3) re-rendering of text labels, captions, descriptive text, etc. using a suitable computer typographic font and typographic styles, 4) using an organization's proprietary diagrams / objects / symbols library to replace hand-drawn counterparts or shorthand codes within the whiteboard image that are identified by the system as referring to such proprietary diagrams / objects / symbols (e.g. a specific component within a software company's system architecture, a specific mechanical widget that forms part of a physical product's construction, a specific navigation pane or other common layout element that occurs consistently throughout different parts of a software product's user interface, etc.).

In order to determine suitable approaches to employ when re-rendering all or parts of a whiteboard image, the module may interpret the data produced by the separate Whiteboard Image Parsing Module, Whiteboard Image Tagging Module, and any other modules of the system that may produce distilled data derived from and characterizing the whiteboard image.

Whiteboard Erasure Recommendation Module

An aspect of the system is a whiteboard erasure recommendation module, which module is responsible for assessing a whiteboard image to determine whether to recommend that a whiteboard containing that image be erased because of a risk of the content of the whiteboard revealing confidential or sensitive information, were the content to be left on the whiteboard.

In order to reach its determination, the module may consider numerous types of information, including but not limited to: 1) semantic information, metadata, and other data characterizing the content of the whiteboard image that is produced during parsing of the image by the separate Whiteboard Image Parsing Module, 2) a location of the whiteboard associated with the whiteboard image, as determined by the separate Whiteboard Location Determiner Module, and information regarding historical and predicted patterns of user traffic to and nearby this location, 3) authorship of the content of the whiteboard image, as determined by the separate Whiteboard Image Authorship Attribution Module, and supplemental data regarding the determined one or more authors of the content, 4) historical information, regarding usage of a meeting room, conference room, or other venue containing the whiteboard associated with the whiteboard image, 5) details of upcoming meeting events scheduled for a meeting room, conference room, or other venue containing the whiteboard associated with the whiteboard image, as determined by integration with one or more calendaring or scheduling services.

Exposure Risk Determination

In order for the module to determine a risk of exposure of the content of a whiteboard to users beyond the initial audience for which the content was intended, the module may consider numerous factors, including but not limited to: 1) the usage pattern of the meeting venue containing the whiteboard, as determined by integration with a calendaring or scheduling system in which the meeting venue is registered as a resource (e.g. a general meeting room may be used by a wide variety of different staff members, whereas a dedicated board room may be used only for board meetings and other meetings of senior executives of an organization), 2) the composition of staff members for an upcoming meeting to be held in the meeting room containing the whiteboard, such as if an upcoming meeting contains members who should not have access to content on the whiteboard, such as, for example, outside guests of the organization, 3) the historical pattern of naturally erasing the whiteboard to make way for new content, in order to determine an estimated natural life expectancy for content on the whiteboard generally and, thereby, estimate an amount of time during which there would be a risk of exposure of the specific whiteboard content in question.

Recommendation Behavior

When it is determined by the Whiteboard Erasure Recommendation Module that a particular whiteboard image should be erased, the module may provide its recommendation according to any of numerous supported methods.

In one case, the module may provide its recommendation to a user immediately upon that user capturing a whiteboard image that the module determines should be erased, which recommendation may take the form of a message displayed to the user in an alert dialog, or as a system message posted to a chat to which the captured whiteboard image is uploaded. In another case, the module may provide its recommendation, or a reminder regarding its recommendation, to the user who captured the whiteboard image towards or at the end of a meeting associated with the whiteboard capture even, or to any or all users who are attending the meeting at the venue associated with the whiteboard, which recommendation or reminder may take the form of a system message posted to a chat to which the captured whiteboard image was uploaded.

In yet other cases, when it is deemed by the module that content within a captured whiteboard image is particularly sensitive in nature, the module may provide its recommendation to select staff members, such as specially designated members of an organization's IT or facilities staff, in the form of an email message sent to each of the staff members, or a chat message posted to each of the staff members in a chat service used by the organization, and which recommendation may instruct the staff members to inspect the venue of the whiteboard after the meeting and erase the whiteboard, if necessary. In such cases, the system of the disclosure may additionally maintain a record of such incidents, in the event that follow-up management actions need to be pursued.

Whiteboard Image Sharing Destination Selector Module

An aspect of the system is a whiteboard image sharing destination selector module, which module is responsible for recommending a suitable destination for sharing a whiteboard image

when a destination is not explicitly selected by the user sharing the image, such as when a user shares an image to a chat client application on a mobile device from a separate camera application on the same mobile device, and which destination may be a user, a group of users, or a chat team comprising a group of users, and the selection of which destination may be informed by various context information, such as: 1) that the user sharing the image is in a scheduled meeting with a group of other users, 2) that the user sharing the image is in a scheduled meeting for a group of users to discuss a topic, where the group of users and the topic of discussion are consistent with a chat team in the collaboration system, 3) that the locational coordinates of the user sharing the image fall within a perimeter around the locational coordinates of a meeting venue that is booked for a scheduled meeting, 4) that the determined one or more authors of the image being shared consists of users other than the user sharing the image, and so on.