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Smart Notifications Based on Priority and Context

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ABSTRACT

Current Operating Systems (OSs) of devices such as desktop computers, laptops, mobile phones, and tablets, provide applications with capabilities to serve information to users via built-in notification mechanisms. If the information presented by a notification is not useful or timely, the user's current task is needlessly disrupted. Moreover, the user is likely to dismiss an inopportune notification quickly, thus reducing user engagement. The techniques of this disclosure enable smart delivery of notifications such that notifications are delivered to the user at an opportune time. On-device neural networks are utilized to make the determination of the opportune time. With user permission, the content of a generated notification is processed to determine whether it is to be shown immediately, by interrupting the user, or whether the delivery is to be deferred until an opportune time.

KEYWORDS

- Push notification
- Smart notification
- Deferred notification
- App notification
- Interruption
- Do Not Disturb
- Notification filtering
- Mobile OS
- User context

BACKGROUND

Current Operating Systems (OSs) of devices such as desktop computers, laptops, mobile phones, and tablets, provide applications with capabilities to serve information to users via built-in notification mechanisms. Such notifications may be used for a wide variety of messages, such as informing the user of an incoming email or instant message, recommending content, presenting customized offers, etc. The notifications follow a push-based approach such that they are pushed to the user device and typically displayed immediately, interrupting the user's ongoing task. If the information presented by the notification is not useful or timely, the user's task is needlessly disrupted. Moreover, the user is likely to dismiss an inopportune notification quickly, thus reducing user engagement, e.g., as indicated by measures such as click-through rates.

The user may avoid interruptions due to notifications via mechanisms such as a "Do Not Disturb" mode that suppress notification delivery. However, such mechanisms suppress all notifications, thus causing the user to miss important or urgent information for which the disruption is acceptable.

DESCRIPTION

The techniques of this disclosure enable smart delivery of notifications such that they are delivered to the user at an opportune time via a system that utilizes on-device neural networks. With user permission, the content of a generated notification is processed to determine whether it is to be shown immediately by interrupting the user, or whether the delivery is to be deferred until an opportune time. If the user does not provide permission to analyze the content of a notification, the described techniques are not implemented, and the device reverts to default behavior, e.g., instant delivery of the notification.

The content of a notification as well as associated metadata, such as originating application, icon, category, etc., serve as inputs to a classifier, e.g., implemented as a machine-learning model that utilizes on-device neural networks. The classifier is trained using training data that includes sample notifications (obtained with permission from users, and pre-processed to remove user-specific information). The training data includes labels for each of the sample notifications, the labels being assigned manually by human coders. The classifier is applied to classify the notification into one or more types, such as interpersonal communication, content recommendation, etc. Simultaneously, the notification content is assigned an attribute, such as urgent, important, etc.

With the user's permission, information from the various device sensors as permitted by the user, such as accelerometer, microphone, gyroscope, etc., are processed by a context model to determine the user's current context and activity, such as writing a document, watching TV, driving, sleeping, in a meeting, on a conference call, etc. The context may also indicate whether the user's current activity is personal, social, or professional.

The notification classification and user context are combined to determine whether the notification is to be shown immediately by interrupting the user. If not, the notification is deferred until the user enters a context suitable for presentation of the notification, thus boosting the likelihood of the user engaging with the notification with minimal disruption. For example, a notification regarding availability of new video content may be deferred until the context model indicates that the user is watching TV or engaged in similar leisure activities. Alternatively, active push-based delivery of a deferred notification may be suppressed entirely. In such cases, passive pull based user interface (UI) mechanisms, such as app badges, drawer icons, etc., may be employed to enable the user to consult the notification on-demand.

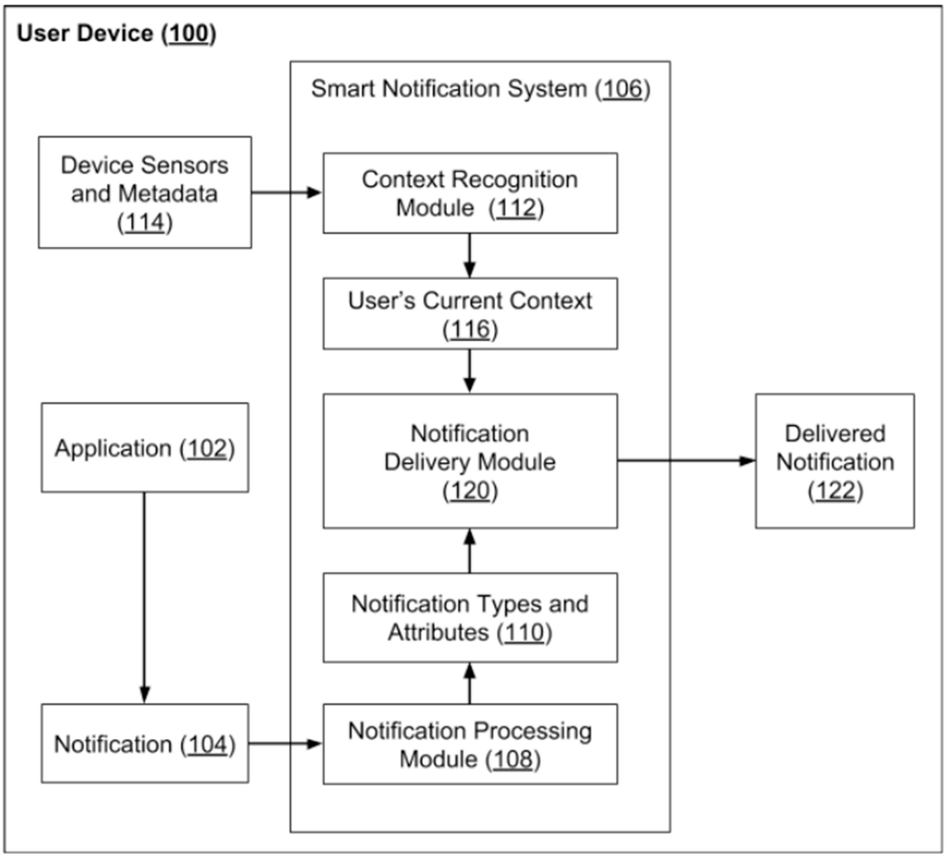

Fig. 1: Determining opportune presentation time and mode for notifications

Fig. 1 shows a user device that implements the techniques of this disclosure. A user device (100) runs an application (102) that generates notification (104). The notification processing module (108) within the smart notification system (106) processes the notification via a trained classifier that generates types and attributes (110) for the notification. If the user permits, the context recognition module (112) of the smart notification system collects information from permitted device sensors as well as other relevant metadata (114) and processes it to predict the user's current context (116).

The notification classification and user context are input to the notification delivery module (120) to determine if the notification (122) should be presented immediately, deferred until an opportune moment, or suppressed completely. Deferred notifications are tracked by the notification delivery module for delivery at an opportune time indicated by the user's context. The smart notifications system is implemented entirely on the user device. This maintains privacy of the notifications and avoids dependence on the availability of network access.

The notification classification model may be, for example, a character-level Long Short-Term Memory (LSTM) neural network, a feedforward Convolutional Neural Network (CNN) using character features, or a fully connected neural network using hash chargram input. Classifications may be performed individually for a single notification, such as in the case of a recurrent model. Alternatively, in some cases, outputs may be averages across multiple notification classifications. The results may be obtained from the output of the classification layer of the module or, if appropriate, from intermediate layer embeddings.

The context model may be a CNN to process sequence data from the device sensors, such as accelerometer, microphone, gyroscope, etc. The context classification is performed over a specified period. Ideally, the operation is continuous, thus ensuring that the latest context is precomputed at a time the notification is received. If continuous processing is infeasible, e.g., due to device or situational constraints, on-demand context processing is performed over a short period window, such as the previous 5 seconds.

The module that determines the optimal time and mode of notification delivery may use a collection of pre-specified rules. In such a case, the users or the application developers may be permitted to specify appropriate rules. Alternatively, or in addition, if the user permits, the module may incorporate a decision model trained based on previous user interactions with notifications.

Examples of use

Example 1: Deferring a non-urgent notification

A smartphone that belongs to a user Martina receives a notification from a restaurant app with the content "25% off if you book a table before 5 pm." The smart notification system detects, with prior permission from Martina, that the device is currently being used to watch a video, and that the current time is 2 pm. Based on the content of the message and the context, the smart notification system defers delivery of the message to a later time, e.g., after the video ends.

Example 2: Delivering an urgent notification immediately

A smartphone that belongs to a user Serena receives a notification from a banking app with the content "one-time password for your transaction at website XYZ is 561335, valid for next 3 minutes." The smart notification system detects, with prior permission from Serena, that the device is currently not in use. Based on the content of the message and the context, the smart notification system delivers the message immediately, allowing the user to complete the transaction. The notification may also be delivered immediately in other contexts, e.g., when the user is using a shopping app on the phone, a browser app on the phone, etc. based on detecting that the notification is urgent, e.g., based on the content "valid for next 3 minutes."

Example 3: Selectively delivering or deferring notification based on context

A smartphone that belongs to a user Gabriela receives a notification from a messaging app with the content "Hi. Call me when you are free." The notification metadata indicates that the message is from Stephanie, a friend that Gabriela has in her address book and that Gabriela frequently communicates with. The smart notification system determines, with prior permission from Gabriela, that the device is currently not in use and the user is currently not in her office. Based on the content of the message and the context, the smart notification system delivers the message immediately. Alternatively, if the smart notification system determines that the user in her office, the smart notification system defers delivery of the message till the context changes, e.g., the location sensor of the smartphone indicates that Gabriela has left office.

Further to the descriptions above, a user may be provided with controls allowing the user to make an election as to both if and when systems, programs or features described herein may enable collection of user information (e.g., information about a user's social network, social actions or activities, profession, a user's preferences, or a user's current location), and if the user is sent content or communications from a server. In addition, certain data may be treated in one or more ways before it is stored or used, so that personally identifiable information is removed. For example, a user's identity may be treated so that no personally identifiable information can be determined for the user, or a user's geographic location may be generalized where location information is obtained (such as to a city, ZIP code, or state level), so that a particular location of a user cannot be determined. Thus, the user may have control over what information is collected about the user, how that information is used, and what information is provided to the user.

CONCLUSION

The techniques of this disclosure enable smart delivery of notifications such that they are delivered to a user at an opportune time. The techniques are implemented via on-device neural networks, such that the privacy of notification content is maintained and without dependence on the availability of network access. With user permission, the content of a generated notification is processed by a trained notification classifier to determine types and attributes for the notification. The notification classification and user context are combined to determine whether the notification is to be shown immediately by interrupting the user. If not, the notification is deferred until the user context is suitable for the presentation of the notification. Alternatively, active push-based delivery of a deferred notification may be suppressed entirely, while allowing the user to consult the notification on-demand when necessary.

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