SYSTEMS AND METHODS FOR COLLECTING RETINAL SIGNAL DATA AND REMOVING ARTIFACTS

CROSS-REFERENCE TO RELATED APPLICATIONS

[01] This application claims the benefit of U.S. Provisional Patent Application No. 63/038,257, filed June 12, 2020, U.S. Provisional Patent Application No. 63/149,508, filed February 15, 2021, International Application No. PCT/CA2021/050390 and U.S. Patent Application No. 17/212,410, both filed on March 25, 2021. Each of the applications named in this paragraph are incorporated by reference herein in their entirety.

FIELD

[02] The present technology relates to systems and methods for collecting and/or processing retinal signal data generated by light stimulation.

BACKGROUND

[03] A signal is a function that conveys information generally about the behavior of a physical or physiological system, or the attributes of some phenomenon. Signal processing is the process of extracting information from a signal. Retinal signal data, such as electroretinograms (ERG) data, may be collected for analysis. The retinal signal data may be collected using sensors such as one or more electrodes attached to an individual. The electrodes may capture electrical signals. A light stimulator may be used to trigger the electrical signals. The retinal signal data may be used by a medical practitioner as a diagnostic aid.

[04] During the capture of retinal signal data, an individual's movements may affect the retinal signal data. This may be more common for individuals that are subject to mental conditions, as these individuals may find it more difficult to remain still while the retinal signal data is captured. Also, these movements may be more likely to occur when the amount of time that the retinal signal data is recorded is extended. ~~It is an object of the present technology~~ Embodiments of the present invention seek to ameliorate at least some of the limitations present in the prior art.

triggered. Retinal signal data occurring after that flash of light may be captured and/or stored for further analysis.

[15] According to a first ~~broad~~ aspect of the present ~~technology~~ invention, there is provided a method executed by at least one processor of a computing system, the method comprising: receiving retinal signal data corresponding to an individual; determining that there are one or more artifacts in the retinal signal data by determining that an impedance of a circuit that collected the retinal signal data has surpassed a threshold impedance of the circuit; modifying the retinal signal data to compensate for the artifacts; and storing the retinal signal data.

[16] In some implementations of the method, modifying the retinal signal data to compensate for the artifacts comprises removing at least a portion of the retinal signal data corresponding to the artifacts.

[17] In some implementations of the method, the method further comprises: receiving calibration data corresponding to the individual; and determining, based on the calibration data, the threshold impedance of the circuit.

[18] In some implementations of the method, the retinal signal data is responsive to at least one flash of light from a light stimulator, wherein the calibration data is collected prior to the at least one flash of light by the same circuit that collected the retinal signal data, and wherein the method further comprises causing the light stimulator to generate the at least one flash of light.

[19] In some implementations of the method, the retinal signal data has a sampling frequency between 4 to 24 kHz.

[20] In some implementations of the method, the retinal signal data is collected for a signal collection time of 200 milliseconds to 500 milliseconds.

[21] In some implementations of the method, the one or more artifacts comprise distortions in the retinal signal data.

[22] In some implementations of the method, the one or more artifacts were caused by one or more of: capture of electrical signals not originating from the retina, shift in electrode positioning,

change in ground or reference electrode contact, photomyoclonic reflex, eye lid blinks, and ocular movements.

[23] In some implementations of the method, the method further comprises: extracting, from the retinal signal data, one or more retinal signal features; extracting, from the retinal signal features, one or more descriptors; applying the one or more descriptors to a first mathematical model and a second mathematical model, wherein the first mathematical model corresponds to a first condition and the second mathematical model corresponds to a second condition, thereby generating a first predicted probability for the first condition and a second predicted probability for the second condition; and outputting the first predicted probability and the second predicted probability.

[24] According to ~~another broad~~ a second aspect of the present invention~~technology~~, there is provided a method executed by at least one processor of a computing system, the method comprising: receiving retinal signal data corresponding to an individual; determining that there are one or more artifacts in the retinal signal data by determining that an impedance of a circuit that collected the retinal signal data has surpassed a threshold impedance of the circuit; storing an indication in the retinal signal data of time periods corresponding to the one or more artifacts; and storing the retinal signal data.

[25] In some implementations of the method, the method further comprises: receiving calibration data corresponding to the individual; and determining, based on the calibration data, the threshold impedance of the circuit.

[26] In some implementations of the method, the method further comprises: determining the time periods corresponding to the one or more artifacts by determining the time periods that an impedance of the retinal signal data surpasses the threshold impedance.

[27] In some implementations of the method, the retinal signal data is responsive to at least one flash of light from a light stimulator, wherein the calibration data is collected prior to the at least one flash of light, and wherein the method further comprises causing the light stimulator to generate the at least one flash of light.

[28] In some implementations of the method, the retinal signal data has a sampling frequency between 4 to 24 kHz.

[29] In some implementations of the method, the retinal signal data is collected for a signal collection time of 200 milliseconds to 500 milliseconds.

[30] In some implementations of the method, the one or more artifacts comprise distortions in the retinal signal data.

[31] In some implementations of the method, the one or more artifacts were caused by one or more of: capture of electrical signals not originating from the retina, shift in electrode positioning, change in ground or reference electrode contact, photomyoclonic reflex, eye lid blinks, and ocular movements.

[32] In some implementations of the method, the method further comprises: extracting, from the retinal signal data, one or more retinal signal features; extracting, from the retinal signal features, one or more descriptors; applying the one or more descriptors to a first mathematical model and a second mathematical model, wherein the first mathematical model corresponds to a first condition and the second mathematical model corresponds to a second condition, thereby generating a first predicted probability for the first condition and a second predicted probability for the second condition; and outputting the first predicted probability and the second predicted probability.

[33] According to ~~another broad~~ a third aspect of the present invention~~technology~~, there is provided a method executed by at least one processor of a computing system, the method comprising:

[34] recording a first set of retinal signal data corresponding to an individual;

[35] determining that there are one or more artifacts in the first set of retinal signal data by determining that an impedance of a circuit that collected the first set of retinal signal data has surpassed a first threshold impedance of the circuit; recording a second set of retinal signal data corresponding to the individual; determining that the impedance of the circuit while recording the second set of retinal signal data has not surpassed a second threshold impedance of the circuit; and storing the second set of retinal signal data.

[36] In some implementations of the method, the method further comprises: recording a first set of calibration data corresponding to the individual before recording the first set of retinal signal data; determining, based on the first set of calibration data, the first threshold impedance of the circuit; recording a second set of calibration data corresponding to the individual before recording the second set of retinal signal data; and determining, based on the second set of calibration data, the second threshold impedance of the circuit.

[37] In some implementations of the method, the method further comprises: after recording the first set of calibration data, triggering a light stimulator to generate a first flash of light based on a set of flash parameters, wherein the first set of retinal signal data is responsive to the first flash of light; and after recording the second set of calibration data, triggering the light stimulator to generate a second flash of light based on the set of flash parameters, wherein the second set of retinal signal data is responsive to the second flash of light.

[38] In some implementations of the method, the first set of retinal signal data and the second set of retinal signal data have a sampling frequency between 4 to 24 kHz.

[39] In some implementations of the method, the first set of retinal signal data and the second set of retinal signal data are collected for a signal collection time of 200 milliseconds to 500 milliseconds.

[40] In some implementations of the method, the method further comprises: extracting, from the second set of retinal signal data, one or more retinal signal features; extracting, from the retinal signal features, one or more descriptors; applying the one or more descriptors to a first mathematical model and a second mathematical model, wherein the first mathematical model corresponds to a first condition and the second mathematical model corresponds to a second condition, thereby generating a first predicted probability for the first condition and a second predicted probability for the second condition; and outputting the first predicted probability and the second predicted probability.

[41] According to ~~another broad~~ a fourth aspect of the present invention~~technology~~, there is provided a method executed by at least one processor of a computing system, the method comprising: receiving retinal signal data corresponding to an individual; inputting the retinal signal data to a machine learning

algorithm (MLA), wherein the MLA was trained using labeled retinal signal data, and wherein each set of retinal signal data in the labeled retinal signal data comprises a label indicating whether the respective set of retinal signal data comprises any artifacts; outputting, by the MLA, adjusted retinal signal data; and storing the adjusted retinal signal data.

[42] In some implementations of the method, the retinal signal data has a sampling frequency between 4 to 24 kHz.

[43] In some implementations of the method, the retinal signal data is collected for a signal collection time of 200 milliseconds to 500 milliseconds.

[44] In some implementations of the method, the MLA removes portions of the retinal signal data corresponding to artifacts.

[45] In some implementations of the method, the MLA adds indicators to the retinal signal data that indicate which portions of the retinal signal data comprise artifacts.

[45A] According to a fifth aspect of the present invention, there is provided a system comprising at least one processor and memory storing a plurality of executable instructions which, when executed by the at least one processor, cause the system to perform the method defined in the first to fourth aspect.

[45B] According to a sixth aspect of the present invention, there is provided a non-transitory computer-readable medium containing instructions which, when executed by a processor, cause the processor to perform the method defined in the first to fourth aspect.

[46] In the context of the present specification, unless expressly provided otherwise, the expression “computer-readable medium” and “memory” are intended to include media of any nature and kind whatsoever, non-limiting examples of which include RAM, ROM, disks (CD-ROMs, DVDs, floppy disks, hard disk drives, etc.), USB keys, flash memory cards, solid state-drives, and tape drives.

[47] In the context of the present specification, a “database” is any structured collection of data, irrespective of its particular structure, the database management software, or the computer hardware on which the data is stored, implemented or otherwise rendered available for use. A database may reside on the same hardware as the process that stores or makes use of the

information stored in the database or it may reside on separate hardware, such as a dedicated server or plurality of servers.

[48] In the context of the present specification, unless expressly provided otherwise, the words "first", "second", "third", etc. have been used as adjectives only for the purpose of allowing for distinction between the nouns that they modify from one another, and not for the purpose of describing any particular relationship between those nouns.

[49] Embodiments of the present technology each have at least one of the above-mentioned ~~object and/or~~ aspects, but do not necessarily have all of them. ~~It should be understood that some aspects of the present technology that have resulted from attempting to attain the above-mentioned object may not satisfy this object and/or may satisfy other objects not specifically recited herein.~~

[50] Additional and/or alternative features, aspects and advantages of embodiments of the present technology will become apparent from the following description, the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[51] For a better understanding of the present technology, as well as other aspects and further features thereof, reference is made to the following description which is to be used in conjunction with the accompanying drawings, where:

[52] Figure 1 is a block diagram of an example computing environment in accordance with various embodiments of the present technology;

[53] Figure 2 is a block diagram of a retinal signal data processing system in accordance with various embodiments of the present technology;

[54] Figure 3 is a diagram of exemplary electrode placement for collecting retinal signal data in accordance with various embodiments of the present technology;

[55] Figure 4 is a flow diagram of a method for compensating for artifacts in retinal signal data in accordance with various embodiments of the present technology;

[56] Figure 5 is a flow diagram of a method for detecting artifacts and outputting an alert during collection of retinal signal data in accordance with various embodiments of the present technology;

[57] Figure 6 is a flow diagram of a method for using a machine learning algorithm (MLA) to remove artifacts from retinal signal data in accordance with various embodiments of the present technology;