

DESCRIPTION

TITLE OF THE INVENTION: METHOD AND APPARATUS FOR DETERMINING DEGREE OF DEMENTIA OF USER

TECHNICAL FIELD

5 The present disclosure relates to a method of determining a degree of dementia of a user, and more particularly, to a method and device for instructing a user to perform a specific action and determining a degree of dementia of a user based on a reaction of the user to the instructed action.

10 BACKGROUND ART

 Dementia is the most severe disease affecting the elderly living with the aging society and has rapidly increased over the decade, and social and economic costs have also rapidly increased. Dementia also causes significant suffering to a patient due to missing or suicide as the patient is unable to live independently and also to a family member caring for the patient. In the case of dementia, early diagnosis and appropriate treatment may prevent or slow further cognitive decline, but the conventional early diagnosis of dementia has a problem. Conventionally, because a patient needs to visit a specialized medical institution, such as a hospital, many of the patients who felt severe forgetfulness and visited the hospital had already developed mild cognitive impairment (MCI) or Alzheimer's disease (AD). Further, a neuro-cognitive function test (SNSB-II, CERAD-K, etc.) requires medical staff with sufficient experience and knowledge to ensure high credibility. In addition, magnetic resonance imaging (MRI), single-photon emission computed tomography (SPECT), positron emission tomography (PET), or a cerebrospinal fluid test is expensive and also causes significant inconvenience to a patient.

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DISCLOSURE OF THE INVENTION

TECHNICAL GOALS

 An embodiment may provide a method and device for determining a degree of dementia of a user.

30 An embodiment may provide a method and device for determining a degree of a user based on a drawing of a user.

TECHNICAL SOLUTIONS

According to an embodiment, a method, performed by an electronic device, of determining a dementia degree of a user may include outputting first content through a user terminal, wherein the first content instructs the user to perform a first task through a first touch action on the user terminal, obtaining first reaction information of the user to the first content through the user terminal, wherein the first reaction information includes at least one of first picture information about a first picture generated by the user as the first task, first time series data obtained with respect to the first touch action, and first structured data related to the first picture, outputting second content through the user terminal, wherein the second content instructs the user to perform a second task through a second touch action on the user terminal, obtaining second reaction information of the user to the second content through the user terminal, obtaining second reaction information of the user to the second content through the user terminal, wherein the second reaction information includes at least one of second picture information about a second picture generated by the user as the second task, second time series data obtained with respect to the second touch action, and second structured data related to the second picture, and determining the dementia degree of the user by inputting the first reaction information and the second reaction information to a dementia degree classification model based on an artificial neural network (ANN) for determining a dementia degree.

The first content and the second content may include an instruction provided as a voice or a text to instruct an action to the user.

The first time series data may include at least one of a time that a digital pen used by the user is in contact with a floor in a pen-down state, a time that the digital pen moves from a stroke to another stroke in a pen-up state, or a distance traveled from a stroke to another stroke while the user performs the first task of the first content.

The first structured data may include a performance score for the first task, the method may further include calculating the performance score for the first task based on the first picture information, and the calculating of the performance score may include segmenting the first picture into a plurality of areas based on the first picture information, normalizing a first target symbol included in a first area of the plurality of areas, determining a first performance score for the first area based on the normalized first target symbol and a first reference symbol that is preset to the first area, and determining the

performance score for the first task based on the first performance score.

The determining of the first performance score for the first area based on the normalized first target symbol and the first reference symbol that is preset to the first area may include determining the first performance score by inputting the normalized first target symbol to a convolutional neural network (CNN) that is pre-updated.

The first structured data may include first parameter information obtained by a digital pen that the user uses while the user performs the first task of the first content, and the first parameter information may include at least one of a first moving speed of the digital pen during a first time that the digital pen is in contact with a touch display of the user terminal, pen pressure during the first time, the number of strokes drawn in a preset time, or a second time that the user does not draw.

The determining of the dementia degree of the user may include generating a first feature by inputting at least one of the first time series data and the second time series data to a pre-updated first ANN, generating a second feature by inputting at least one of the first structured data and the second structured data to a pre-updated second ANN, generating a concatenated feature by inputting the first feature and the second feature to an ANN-based concatenate layer, and determining the dementia degree of the user by inputting the concatenated feature to an ANN-based fully connected layer.

The method may further include outputting third content through the user terminal, wherein the third content instructs the user to perform a third task through a third touch action on the user terminal, and obtaining third reaction information of the user to the third content through the user terminal, wherein the third reaction information may include at least one of third picture information about a third picture generated by the user as the first task, third time series data obtained with respect the third touch action, and third structured data related to the third picture.

The dementia degree may be one of normal, subjective cognitive impairment (SCI), mild cognitive impairment (MCI), and Alzheimer's disease (AD).

The determined dementia degree may be output through the user terminal.

According to an embodiment, a non-transitory computer-readable storage medium may store a program to perform the method.

According to an embodiment, an electronic device for determining a dementia degree of a user may include a memory storing a program for determining a dementia

degree of a user, and a processor configured to perform the program, wherein the program is configured to perform outputting first content through a user terminal, wherein the first content instructs the user to perform a first task through a first touch action on the user terminal, obtaining first reaction information of the user to the first content through the user terminal, wherein the first reaction information includes at least one of first picture information about a first picture generated by the user as the first task, first time series data obtained with respect to the first touch action, and first structured data related to the first picture, outputting second content through the user terminal, wherein the second content instructs the user to perform a second task through a second touch action on the user terminal, obtaining second reaction information of the user to the second content through the user terminal, obtaining second reaction information of the user to the second content through the user terminal, wherein the second reaction information includes at least one of second picture information about a second picture generated by the user as the second task, second time series data obtained with respect to the second touch action, and second structured data related to the second picture, and determining the dementia degree of the user by inputting the first reaction information and the second reaction information to a dementia degree classification model based on an ANN for determining a dementia degree.

EFFECTS OF THE INVENTION

A method and device for determining a degree of dementia of a user may be provided.

A device and method of determining a degree of dementia of a user based on a drawing of the user may be provided.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a diagram of a configuration of a system for determining a degree of dementia of a user, according to an embodiment.

FIG. 2 illustrates images output on a user terminal to determine a degree of dementia of a user, according to an embodiment.

FIG. 3 is a diagram of a configuration of an electronic device for determining a degree of dementia of a user, according to an embodiment.

FIG. 4 is a flowchart of a method of determining a degree of dementia of a user, according to an embodiment.

FIG. 5 is a flowchart of a method of determining a degree of dementia of a user, according to an embodiment.

5 FIGS. 6, 7A, 7B, and 8 illustrate pre-produced contents according to various embodiments.

FIG. 9 is a flowchart of a method of calculating a performance score of structured data, according to an embodiment.

10 FIG. 10 is a flowchart of a method of determining a degree of dementia using a dementia degree classification model, according to an embodiment.

BEST MODE FOR CARRYING OUT THE INVENTION

The following detailed structural or functional description is provided as an example only and various alterations and modifications may be made to the embodiments.
15 Accordingly, the embodiments are not construed as limited to the disclosure and should be understood to include all changes, equivalents, and replacements within the idea and the technical scope of the disclosure.

Although terms, such as first, second, and the like are used to describe various components, the components are not limited to the terms. These terms should be used
20 only to distinguish one component from another component. For example, a first component may be referred to as a second component, and similarly, the second component may also be referred to as the first component.

It should be noted that if it is described that one component is "connected", "coupled", or "joined" to another component, a third component may be "connected",
25 "coupled", and "joined" between the first and second components, although the first component may be directly connected, coupled, or joined to the second component.

As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises/comprising" and/or "includes/including" when used
30 herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components and/or groups thereof.

Unless otherwise defined, all terms, including technical and scientific terms, used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the present disclosure pertains. It will be further understood that terms, such as those defined in commonly-used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

Hereinafter, embodiments will be described in detail with reference to the accompanying drawings. When describing the embodiments with reference to the accompanying drawings, like reference numerals refer to like elements and a repeated description related thereto will be omitted.

FIG. 1 is a diagram of a configuration of a system for determining a degree of dementia of a user, according to an embodiment.

According to an embodiment, a system for determining a degree of dementia of a user may include an electronic device 110 for determining the degree of dementia of the user, a user terminal 120 for outputting content, and a monitoring terminal 130 of a medical institution. For example, the electronic device 110 may be a server.

The electronic device 110 may provide, to the user terminal 120, pre-produced content to determine the degree of dementia of the user. The content may be intended to obtain a drawing (or a picture) from the user. The content may instruct the user to perform a task through a touch action. The user may draw a picture using the user terminal 120 as a task. The content output through the user terminal 120 to obtain a drawing from the user is further described below with reference to FIGS. 6 to 8.

For example, the user terminal 120 may be a mobile device, such as a tablet personal computer (PC) including a touch display or a smartphone. For another example, the user terminal 120 may be an electronic device to which a tablet is connected as an input tool. The user may draw a picture through the user terminal 120 using a tool, such as a digital pen, or a direct touch by a hand.

The user terminal 120 may be connected to the electronic device 110 via offline or online and may communicate with the electronic device 110. The electronic device 110 may provide the content to the user terminal 120 and the user terminal 120 may output the content to the user through the display. For example, the user terminal 120 may

receive the drawing from the user through the touch display or the tablet. The user terminal 120 may output the drawing by the user through a display (or a touch display) of the user terminal 120.

When the user draws a picture using the digital pen, the user terminal 120 may receive pen information from the digital pen. The user terminal 120 may transmit drawing information on the obtained drawing and the pen information to the electronic device 110.

When the user terminal 120 is a mobile terminal, the user may not be restricted by time and space and the dementia degree may be measured as a low cost.

Hereinafter, the method of determining the degree of dementia of the user is further described with reference to FIGS. 2 to 10.

FIG. 2 illustrates images output on a user terminal to determine a degree of dementia of a user according to an embodiment.

Following images 210 to 240 may be images of an application for determining the degree of dementia. For example, the user of the electronic device 110 may create and distribute the application and the user may execute the application through the user terminal 120.

The first image 210 may be a start screen of the application.

The second image 220 may indicate functions supported by the application.

The third image 230 may be an example of content provided to the user. One or more contents may be provided to the user.

The fourth image 240 may indicate a determined degree of dementia of the user. For example, normal, subjective cognitive impairment (SCI), mild cognitive impairment (MCI), or Alzheimer's disease (AD) may be output as the determined degree of dementia of the user. For example, a score or a probability of the degree of dementia of the user may be output. A comprehensive determination may also be output other than a level of attention to individual disease.

FIG. 3 is a diagram of a configuration of an electronic device for determining a degree of dementia of a user according to an embodiment.

An electronic device 300 may include a communication unit 310, a processor 320, and a memory 330. For example, the electronic device 300 may be the electronic device 110 described above with reference to FIG. 1.

The communication unit 310 may be connected to the processor 320 and the memory 330 to transmit and receive data. The communication unit 310 may be connected to other external devices to transmit and receive data. Hereinafter, the expression transmit and receive "A" may refer to transmit and receive "information or data indicating A".

The communication unit 310 may be implemented by a circuitry in the electronic device 300. For example, the communication unit 310 may include an internal bus and an external bus. For another example, the communication unit 310 may be an element to connect the electronic device 300 to an external device. The communication unit 310 may be an interface. The communication unit 310 may receive data from an external device and may transmit the data to the processor 320 and the memory 330.

The processor 320 may process the data that the communication unit 310 receives and the data stored in the memory 330. The "processor" may be a data processing device implemented by hardware including a circuit having a physical structure to perform desired operations. For example, the desired operations may include code or instructions included in a program. For example, the hardware-implemented data processing device may include a microprocessor, a central processing unit (CPU), a processor core, a multi-core processor, a multiprocessor, an application-specific integrated circuit (ASIC), and a field-programmable gate array (FPGA).

The processor 320 may execute instructions triggered by the processor 320 and computer-readable code (e.g., software) stored in a memory (e.g., the memory 330).

The memory 330 may store data that the communication unit 310 receives and the data processed by the processor 320. For example, the memory 330 may store a program (or an application or software). The stored program may be a set of syntaxes that are coded to determine the degree of dementia of the user and are executable by the processor 320.

According to an aspect, the memory 330 may include at least one volatile memory, non-volatile memory, random access memory (RAM), flash memory, a hard disk drive, and an optical disk drive.

The memory 330 may store a set of instructions (e.g., software) to operate the electronic device 300. The set of instructions to operate the electronic device 300 may be executed by the processor 320.

FIG. 4 is a flowchart of a method of determining a degree of dementia of a user according to an embodiment.

Operations 410 to 450 may be performed by the electronic device 300 (hereinafter, referred to as the electronic device) described above with reference to FIG.

5 3.

In operation 410, the electronic device may output first content through a user terminal (e.g., the user terminal 120 of FIG. 1). The first content may instruct a user to perform a first task by a first touch action to the user terminal. For example, the first content may include an instruction provided as text or a voice for instructing an action to the user. The first content may be output on the user terminal and the user may draw a first picture as the first task to the first content using the user terminal.

According to an embodiment, the first touch action may be obtained by drawing the picture by the user by directly touching a touch display or tablet of the user terminal with a hand of the user.

15 According to an embodiment, the first touch action may be obtained by drawing the picture by the user on the touch display or tablet of the user terminal using a digital pen.

The user terminal may receive the first picture generated as the first task to the first content through the touch display or the tablet. In addition, the user terminal may receive pen information on the first picture from the digital pen connected to the user terminal by wire or wirelessly.

According to an embodiment, the pen information on the first picture may include at least one of first parameter information and first time series data obtained by the digital pen while the user performs the first task.

25 The user terminal may generate first picture information on the first picture. The user terminal may transmit at least one of the first picture information on the first picture drawn by the user and the first pen information to the electronic device.

In operation 420, the electronic device may obtain information on a first reaction (hereinafter, also referred to as the first reaction information) of the user to the first content through the user terminal. The first reaction information may include at least one of the first picture information on the first picture generated by the user as the first task, the first time series data obtained by the first touch action, and first structured data

related to the first picture.

According to an embodiment, the first picture information on the first picture may include information on a total size of the first picture and information like pixel information.

- 5 According to an embodiment, the first time series data obtained by the first touch action to the first picture may include feature elements of Table 1 shown below.

[Table 1]

Feature elements	Details
time on surface	a time that the digital pen is in contact with a floor in a pen-down state
time in air	a time that the digital pen moves from one stroke to another stroke in a pen-up state
pen-up stroke length	a distance traveled from one stroke to another stroke

- 10 In Table 1, time on surface may be a time that the digital pen is in contact with the touch display of the user terminal. Time in air may be a time that the digital pen is not in contact with the touch display.

According to an embodiment, the first structured data related to the first picture may include at least one of a performance score for the first task and first parameter information. The first structured data may include data in the form of scalars or vectors.

- 15 The method of determining the performance score for the first task is further described below with reference to FIG. 9.

The first parameter information may include feature elements of Table 2 shown below.

[Table 2]

Feature elements	Details
velocity on surface	speed of drawing
velocity in air	moving speed of digital pen
pressure	pressure
pressure_velocity_relation	relationship between pen pressure and velocity
strokes per minute	number of drawn strokes per minute

time not painting	intermission
pressure_variability	change in pen pressure
horizontal_inclination_variability	change in horizontal angle of digital pen
vertical_inclination_variability	change in vertical angle of digital pen
total time	sum of time in air and time on surface

In [Table 2], total time may be a sum of time on surface and time in air. Velocity on surface may be first moving speed of the digital pen during the time on surface in which the digital pen is in contact with the touch display of the user terminal. Velocity in air may be second moving speed of the digital pen during the time in air. The second moving speed may be calculated based on the time in air and the pen-up stroke length. Pressure may be pen pressure during the time on surface. Strokes per minute may be the number of strokes drawn in a preset time (e.g., 1 minute). Time not painting may be the time in which the user does not draw.

In operation 430, the electronic device may output second content through the user terminal. The second content may instruct the user to perform a second task that is different from the first task of the first content described above, through a second touch action to the user terminal. For example, the second content may include an instruction provided as text or a voice for instructing an action to the user. The second content may be output on the user terminal and the user may draw a second picture as the second task to the second content using the user terminal.

According to an embodiment, the second touch action may be obtained as the user draws the picture by directly touching the touch display or tablet of the user terminal with a hand of the user.

According to an embodiment, the second touch action may be obtained as the user draws the picture on the touch display or tablet of the user terminal using the digital pen.

The user terminal may receive the second picture generated as the second task to the second content through the touch display or the tablet. In addition, the user terminal may receive pen information on the second picture from the digital pen connected to the

user terminal by wire or wirelessly.

According to an embodiment, the pen information on the second picture may include at least one of second parameter information and second time series data obtained by the digital pen while the user performs the second task.

5 The user terminal may generate second picture information on the second picture. The user terminal may transmit at least one of the second picture information on the second picture drawn by the user and the second pen information to the electronic device.

10 In operation 440, the electronic device may obtain information on a second reaction (hereinafter, also referred to as the second reaction information) of the user to the second content through the user terminal. The second reaction information may include at least one of the second picture information on the second picture generated by the user as the second task, the second time series data obtained by the second touch action, and second structured data related to the second picture.

15 According to an embodiment, the second picture information on the second picture may include information on a total size of the second picture and information like pixel information.

According to an embodiment, the second time series data obtained by the second touch action to the second picture may include the feature elements of Table 1.

20 According to an embodiment, the second structured data related to the second picture may include at least one of performance information on the second task and the second parameter information. The second structured data may include data in the form of scalars or vectors.

25 The performance information on the second task is further described below with reference to FIGS. 7A and 7B. The second parameter information may include the feature elements of Table 2.

In operation 450, the electronic device may determine the dementia degree of the user by inputting the first reaction information and the second reaction information to an artificial neural network (ANN)-based dementia degree classification model to determine the dementia degree.

30 The method of determining the dementia degree of the user by inputting the first reaction information and the second reaction information to the ANN-based dementia degree classification model according to an embodiment is further described with

reference to FIG. 10.

According to an embodiment, the dementia degree may be one of normal, SCI, MCI, and AD.

According to an embodiment, the dementia degree may include a score or a probability for at least one of normal, SCI, MCI, and AD.

After operation 450 is performed, the electronic device may output the determined dementia degree through the user terminal.

FIG. 5 is a flowchart of a method of determining a degree of dementia of a user according to an embodiment.

According to an embodiment, the method of determining the dementia degree described above with reference to FIG. 4 may further include operations 510 and 520 described below. For example, operations 510 and 520 may be performed after operation 440 of FIG. 4.

Operations 510 and 520 may be performed by the electronic device 300 (hereinafter, the electronic device) described above with reference to FIG. 3.

In operation 510, the electronic device may output third content through a user terminal (e.g., the user terminal 120 of FIG. 1). The third content may instruct the user to perform a third task that is different from the first task of the first content and the second task of the second content that are described above, through a third touch action to the user terminal. For example, the third content may include an instruction provided as text or a voice for instructing an action to the user. The third content may be output on the user terminal and the user may draw a third picture as the third task to the third content.

According to an embodiment, the third touch action may obtain the picture as the user draws the picture by directly touching the touch display or tablet of the user terminal with a hand of the user.

According to an embodiment, the third touch action may obtain the picture as the user draws the picture on the touch display or tablet of the user terminal using the digital pen.

The user terminal may receive the third picture generated as the third task to the third content through the touch display or the tablet and in addition, may receive pen information on the third picture from the digital pen that is connected to the user terminal by wire or wirelessly.

According to an embodiment, the pen information on the third picture may include at least one of third parameter information and third time series data obtained by the digital pen while the user performs the third task.

The user terminal may generate third picture information on the third picture.
 5 The user terminal may transmit at least one of the third picture information on the third picture drawn by the user and the third pen information to the electronic device.

In operation 520, the electronic device may obtain information on a third reaction (hereinafter, also referred to as the third reaction information) of the user to the third content through the user terminal. The third reaction information may include at least
 10 one of the third picture information on the third picture generated by the user as the third task, the third time series data obtained by the third touch action, and third structured data related to the third picture.

According to an embodiment, the third picture information on the third picture may include information on a total size of the third picture and information like pixel
 15 information.

According to an embodiment, the third time series data obtained by the third touch action to the third picture may include the feature elements of Table 1.

According to an embodiment, the third structured data related to the third picture may include at least one of performance information on the third task and the third
 20 parameter information. The third structured data may include data in the form of scalars or vectors.

The performance information on the third task is further described below with reference to FIG. 8. The third parameter information may include the feature elements of Table 2.

25 After operation 520 is performed, the electronic device may perform operation 450 of FIG. 4 to determine the dementia degree of the user. In operation 450, the electronic device may determine the dementia degree of the user by inputting the first reaction information, the second reaction information, and the third reaction information to the ANN-based dementia degree classification model to determine the dementia degree.

30 The method of determining the dementia degree of the user by inputting the first reaction information, the second reaction information, and the third reaction information to the ANN-based dementia degree classification model according to an embodiment is

further described with reference to FIG. 10.

After operation 450 is performed, the electronic device may output the determined dementia degree through the user terminal.

FIGS. 6, 7A, 7B, and 8 illustrate pre-produced contents according to various
5 embodiments.

The content may be output on a display 610, 710, 720, 810 (e.g., a touch display) of a user terminal (e.g., the user terminal 120 of FIG. 1). The content may transmit an instruction on the content to the user. The content may instruct the user to perform a task through a touch action. For example, the instruction may be output as text 611, 711,
10 721, 811. For another example, the instruction may be output as sound.

FIG. 6 illustrates first content provided to the user, according to an embodiment.

According to an embodiment, the first content may be content to induce the user to perform a task of viewing a symbol table provided to the user and drawing a symbol (or a sign) corresponding to a specific number.

According to an embodiment, the first content may output a preset reference
15 symbol table and an example picture in advance. For example, the first content may output a table segmented into a plurality of areas in which the user draws respective pictures of symbols in advance.

According to an embodiment, the user may draw pictures of symbols respectively
20 corresponding to given numbers through a tablet connected to the user terminal or the display 610 using the digital pen. For example, the user may draw a symbol corresponding to number 7 in an area 613. For example, after completing the drawing of the symbols corresponding to all numbers, the user may terminate the provision of the first content by touching a submit button 612. The user terminal may generate picture
25 information on the picture drawn by the user. The user terminal may transmit the picture information to the electronic device (e.g., the electronic device 300).

The picture drawn by each user may have various features but as the dementia degree increases, a performance score of a correctly drawn symbol may decrease.

FIGS. 7A and 7B illustrate second content provided to the user, according to an
30 embodiment.

According to an embodiment, the second content may be content to induce the user to perform a task of viewing numbers and/or letters and drawing strokes to connect

them sequentially.

According to an embodiment, the second content may output numbers and/or letters with preset start and end points in advance.

According to an embodiment, the user may draw strokes for connecting numbers
 5 and/or letters in an order indicated by the text 711, 721 through the tablet connected to
 the user terminal or the display 710, 720 using the digital pen. For example, the user
 may draw a picture 713 in which the numbers are sequentially connected or a picture 723
 in which numbers and letters are sequentially and alternately connected. Depending on
 the task of the second content, the user may draw a picture in which the numbers are
 10 connected in ascending or descending order. For another example, the user may draw a
 picture in which among duplicate numbers in different colors, numbers in different colors
 are sequentially connected.

According to an embodiment, when the user connects the numbers and/or the
 letters in an incorrect order, the second content may provide feedback, such as outputting
 15 an alert sound.

According to an embodiment, after completing the drawing of the picture of
 strokes for connecting all numbers and/or letters, the user may terminate the provision of
 the second content by touching a submit button 712, 722. The user terminal may
 generate picture information on the picture 713, 723 drawn by the user.

20 According to an embodiment, when the user fails to complete the task in a
 predetermined time, the provision of the second content may be forcibly terminated after
 the predetermined time has elapsed. The user terminal may generate picture information
 on an unfinished picture drawn by the user. The user terminal may transmit the picture
 information to the electronic device.

25 According to an embodiment, the user terminal may generate performance
 information on the second content. The performance information on the second content
 may include data in the form of scalars or vectors on the stroke of the picture. The
 performance information on the second content may include at least one of whether the
 user performs all tasks, a total time taken to perform the tasks, and information on to
 30 which level (or a point) the user performs the task. The user terminal may transmit the
 performance information on the second content to the electronic device.

The pictures drawn by each user may have various features, but as the dementia

degree increases, the time taken by the user to perform the task may increase or the performance level may decrease.

FIG. 8 illustrates third content provided to the user, according to an embodiment.

According to an embodiment, the third content may be content to induce the user
5 to perform a task of drawing a clock with needles indicating a specific time (e.g., 11:10).

According to an embodiment, the third content may output an outer shape (e.g., a circular shape) of the clock in advance.

According to an embodiment, the user may draw a picture 813 of the clock with needles indicating a specific time through the display 810 or the tablet connected to the
10 user terminal using the digital pen. For example, after completing the picture, the user may terminate the provision of the third content by touching a submit button 812. The user terminal may generate picture information on the picture 813 drawn by the user. The user terminal may transmit the picture information to the electronic device.

According to an embodiment, the electronic device may determine performance
15 information on the picture (hereinafter, also referred to as the third picture) generated by the user as the task of the third content. The electronic device may normalize the third picture based on the third picture information on the third picture. The electronic device may set, to region of interest (ROI), an area in which the picture is actually drawn from a total area of the third picture. The electronic device may normalize the picture by
20 adjusting the ROI to a normalized size.

According to an embodiment, normalization information, which is information on the normalized picture, may be further generated. The size and/or a ratio of the adjusted ROI may be generated as the normalization information.

According to an embodiment, the electronic device may input the normalized
25 picture to a pre-updated neural network. For example, the pre-updated neural network may be a neural network based on a convolutional neural network (CNN) and/or a deep neural network (DNN). According to an embodiment, the normalization information may be further input to the pre-updated neural network.

According to an embodiment, the electronic device may calculate a balance score
30 for the normalized information as the performance information of the third task. For example, the calculated balance score may be a value in a preset range (e.g., between 0 and 5). The electronic device may calculate the balance score by separating elements of

the picture and determining a degree of balance among the separated elements. Segmentation may be performed first on the picture to determine the elements. For example, a first element indicating an arrangement of numbers indicating the times of the clock and a second element indicating an arrangement of the needles may be determined
 5 and the balance score may be calculated based on a balance between the first element and the second element. For example, as the symmetry of the arranged times increases, the balance score may increase. For another example, as appropriateness of the size of the first element and the size of the second element increases, the balance score may increase.

The pictures drawn by each user may have various features, but as the dementia
 10 degree increases, a shape of the clock and the time indicated by the clock may be unclear.

FIG. 9 is a flowchart of a method of calculating a performance score of structured data according to an embodiment.

According to an embodiment, the method of determining the dementia degree described above with reference to FIG. 4 or 5 may further include operation 900 described
 15 below. Operation 900 may be performed after operation 420 of FIG. 4.

Operation 900 described below may be performed by the electronic device 300 (hereinafter, also referred to as the electronic device) described above with reference to FIG. 3.

According to an embodiment, the first structured data related to the first picture
 20 may include a performance score for the first task. In operation 900, the electronic device may calculate the performance score for the first task based on the first picture information.

According to an embodiment, operation 900 may include operations 910 to 940 described below.

25 In operation 910, the electronic device may segment the first picture into a plurality of areas based on the first picture information. The first picture may represent a picture of symbols only drawn by the user other than the preset reference symbol table, the example picture, and the table for drawing the symbols that are output by the first content in advance. For example, among a first layer on elements output by the first
 30 content in advance and a second layer generated by a first touch input of the user, the first picture may represent a picture of the second layer.

According to an embodiment, the electronic device may segment the first picture

so that each area includes one symbol corresponding to one number. For example, the electronic device may segment the first picture into a plurality of areas corresponding to segmented areas of the table for drawing a pre-output symbol. Accordingly, the plurality of areas may be areas at fixed positions rather than areas at variable positions in which the actual picture is drawn.

In operation 920, the electronic device may normalize a first target symbol included in a first area of the plurality of areas.

Hereinafter, for ease of description, a description is provided based on a case in which the first area is the area 613 in which the picture of the symbol corresponding to number 7 of FIG. 6 is drawn. The first area may include the first target symbol corresponding to number 7.

According to an aspect, when the dementia degree of the user is high, the first target symbol may partially deviate from the first area or may be included in an area other than the first area. The electronic device may perform the following processing on a portion of the first target symbol drawn in the first area. When the first target symbol significantly deviates from the first area or is included in an area other than the first area, the electronic device may determine a first performance score for the first area to be 0.

According to an embodiment, the electronic device may set an area in which the picture of the first target symbol is actually drawn in the first area to the ROI. The electronic device may adjust the ROI to a preset size. The electronic device may normalize the first target symbol by normalizing a pixel value for the adjusted ROI. For example, the electronic device may normalize the first target symbol in a range of [0, 1]. For example, the electronic device may generate a normalized picture for the first target symbol or may generate normalization information including each pixel value of the normalized first target symbol.

In operation 930, the electronic device may determine the first performance score for the first area based on the normalized first target symbol and a first reference symbol that is preset to the first area. For example, as shown in the reference symbol table of FIG. 6, a triangle symbol may be preset to the first reference symbol for the first area.

According to an embodiment, the electronic device may input the normalized first target symbol to a pre-updated neural network. For example, the pre-updated neural network may be a CNN-based neural network. The electronic device may input, to a

fully connected layer, output data that is generated by inputting the normalized first target symbol to the CNN.

According to an embodiment, when the first target symbol corresponds to the first reference symbol (e.g., when the similarity is greater than or equal to a threshold level) based on the pre-updated neural network, the electronic device may determine the first performance score to be a preset score for a ground truth answer.

According to an embodiment, when the first target symbol does not correspond to the first reference symbol based on the pre-updated neural network, the electronic device may determine the first performance score to be 0.

In operation 940, the electronic device may determine a performance score for the first task based on the first performance score. The electronic device may determine performance scores for each of the plurality of areas of the first picture and may determine the performance score for the first task by aggregating the performance scores for all areas. For example, among the plurality of areas, the electronic device may determine the number of areas that are ground truth answers to be the performance score.

FIG. 10 is a flowchart of a method of determining a degree of dementia using a dementia degree classification model according to an embodiment.

According to an embodiment, operation 450 described above with reference to FIG. 4 may further include operations 1010 to 1040 described below.

Operations 1010 to 1040 may be performed by the electronic device 300 (hereinafter, referred to as the electronic device) described above with reference to FIG. 3.

According to an embodiment, the electronic device may determine a dementia degree of a user using a dementia degree classification model. The dementia degree classification model may include a first ANN, a second ANN, a concatenate layer, and a fully connected layer. The electronic device may update the dementia degree classification model in advance to determine the dementia degree of the user.

According to an embodiment, the electronic device may obtain test reaction information of a test user for first content and second content. The electronic device may determine a test dementia degree for the test user by inputting, to the dementia degree classification model, the test reaction information in which a ground truth (GT) dementia degree of the test user is labeled. The electronic device may update the dementia degree

classification model based on the test dementia degree and the GT dementia degree.

In operation 1010, the electronic device may generate a first feature by inputting at least one of first time series data and second time series data to the first ANN that is pre-updated. For example, the first ANN may include a transformer or a long short-term memory (LSTM) layer.

According to an embodiment, the electronic device may preprocess the first time series data and/or the second time series data and may input the preprocessed first time series data and the preprocessed second time series data to the first ANN. The electronic device may generate the preprocessed first time series data and/or the preprocessed second time series data by performing min-max scaling and differencing on the first time series data and/or the second time series data. The electronic device may generate the first feature by inputting the preprocessed first time series data and/or the preprocessed second time series data to the first ANN.

In operation 1020, the electronic device may generate a second feature by inputting at least one of first structured data and second structured data to the second ANN that is pre-updated. For example, the second ANN may include a fully connected layer (or a dense layer).

According to an embodiment, the electronic device may preprocess the first structured data and/or the second structured data and may input the preprocessed first structured data and/or the preprocessed second structured data to the second ANN. The electronic device may generate the preprocessed first structured data and/or the preprocessed second structured data by normalizing the first structured data and/or the second structured data by performing min-max scaling or standard scaling thereon and filtering the normalized first structured data and/or the normalized second structured data based on a correlation. The electronic device may remove data with low correlation or variables with multicollinearity by measuring a variance inflation factor (VIF) through preprocessing and may adjust the data to prevent an outlier or kurtosis in the data. The electronic device may generate the second feature by inputting the preprocessed first structured data and/or the preprocessed second structured to the second ANN.

In operation 1030, the electronic device may generate a concatenated feature by inputting the first feature and the second feature to an ANN-based concatenate layer.

According to an embodiment, an order of concatenating the first feature and the

second feature to determine the dementia degree may be the same as the order of concatenating features generated by inputting the time series data and the structured data included in the test reaction information to the first ANN and the second ANN, respectively, in a process of pre-updating the dementia degree classification model.

5 According to an embodiment, as described with reference to FIG. 5, the electronic device may obtain information on a third reaction of the user to the third content. The electronic device may update the dementia degree classification model as described above by obtaining the test reaction information of the test user to the first content, the second content, and the third content. In this case, the dementia degree classification
10 model may further include a third ANN.

 According to an embodiment, the electronic device may generate a third feature by inputting, to the third ANN that is pre-updated, a third picture (or third picture information on the third picture) generated by the user for the third content. For example, the third ANN may be the same as or different from the pre-updated neural network
15 described with reference to FIG. 8. For example, the third ANN may include a vision transformer. As described with reference to FIG. 8, a normalized picture for the third picture and/or the normalization information may be input to the third ANN.

 As described in operations 1010 to 1030, the electronic device may generate the first feature by inputting at least one of the first time series data, the second time series
20 data, the third time series data to the pre-updated first ANN, may generate the second feature by inputting at least one of the first structured data, the second structured data, and the third structured data to the pre-updated second ANN, and may generate the concatenated feature by inputting the first feature, the second feature, and the third feature to the ANN-based concatenate layer.

25 According to an embodiment, the order of concatenating the first feature, the second feature, and the third feature to determine the dementia degree may be the same as the order of concatenating the features generated by inputting the time series data, the structured data, and the picture information included in the test reaction information to the first ANN, the second ANN, and the third ANN, respectively, in the process of pre-
30 updating the dementia degree classification model.

 In operation 1040, the electronic device may determine the dementia degree of the user by inputting the concatenated feature to an ANN-based fully connected layer.

According to an embodiment, the dementia degree may be one of normal, SCI, MCI, and AD.

According to an embodiment, the dementia degree may include a score or a probability for at least one of normal, SCI, MCI, and AD.

5 The embodiments described herein may be implemented using a hardware component, a software component and/or a combination thereof. A processing device may be implemented using one or more general-purpose or special-purpose computers, such as, for example, a processor, a controller and an arithmetic logic unit (ALU), a DSP, a microcomputer, an FPGA, a programmable logic unit (PLU), a microprocessor or any
10 other device capable of responding to and executing instructions in a defined manner. The processing device may run an operating system (OS) and one or more software applications that run on the OS. The processing device also may access, store, manipulate, process, and create data in response to execution of the software. For purpose of simplicity, the description of a processing device is used as singular; however,
15 one skilled in the art will appreciate that a processing device may include multiple processing elements and multiple types of processing elements. For example, the processing device may include a plurality of processors, or a single processor and a single controller. In addition, different processing configurations are possible, such as parallel processors.

20 The software may include a computer program, a piece of code, an instruction, or some combination thereof, to independently or uniformly instruct or configure the processing device to operate as desired. Software and data may be stored in any type of machine, component, physical or virtual equipment, or computer storage medium or device capable of providing instructions or data to or being interpreted by the processing
25 device. The software also may be distributed over network-coupled computer systems so that the software is stored and executed in a distributed fashion. The software and data may be stored by one or more non-transitory computer-readable recording mediums.

 The methods according to the above-described embodiments may be recorded in non-transitory computer-readable media including program instructions to implement
30 various operations of the above-described embodiments. The media may also include, alone or in combination with the program instructions, data files, data structures, and the like. The program instructions recorded on the media may be those specially designed

and constructed for the purposes of example embodiments, or they may be of the kind well-known and available to those having skill in the computer software arts. Examples of non-transitory computer-readable media include magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD-ROM discs, DVDs, and/or
5 Blue-ray discs; magneto-optical media such as optical discs; and hardware devices that are specially configured to store and perform program instructions, such as read-only memory (ROM), random access memory (RAM), flash memory (e.g., USB flash drives, memory cards, memory sticks, etc.), and the like. Examples of program instructions include both machine code, such as produced by a compiler, and files containing higher-
10 level code that may be executed by the computer using an interpreter.

The above-described hardware devices may be configured to act as one or more software modules in order to perform the operations of the above-described examples, or vice versa.

As described above, although the embodiments have been described with
15 reference to the limited drawings, a person skilled in the art may apply various technical modifications and variations based thereon. For example, suitable results may be achieved if the described techniques are performed in a different order and/or if components in a described system, architecture, device, or circuit are combined in a different manner and/or replaced or supplemented by other components or their
20 equivalents.

Accordingly, other implementations are within the scope of the following claims.

CLAIMS

- [Claim 1] A method, performed by an electronic device, of determining a dementia degree of a user, the method comprising:
- 5 outputting first content through a user terminal, wherein the first content instructs the user to perform a first task through a first touch action on the user terminal;
- obtaining first reaction information of the user to the first content through the user terminal, wherein the first reaction information comprises at least one of first picture information about a first picture generated by the user as the first task, first time series data obtained with respect to the first touch action, and first structured data related to the first picture;
- 10 outputting second content through the user terminal, wherein the second content instructs the user to perform a second task through a second touch action on the user terminal;
- 15 obtaining second reaction information of the user to the second content through the user terminal, obtaining second reaction information of the user to the second content through the user terminal, wherein the second reaction information comprises at least one of second picture information about a second picture generated by the user as the second task, second time series data obtained with respect to the second touch action, and second structured data related to the second picture; and
- 20 determining the dementia degree of the user by inputting the first reaction information and the second reaction information to a dementia degree classification model based on an artificial neural network (ANN) for determining a dementia degree.
- 25 [Claim 2] The method of claim 1, wherein the first content and the second content comprise an instruction provided as a voice or a text to instruct an action to the user.
- [Claim 3] The method of claim 1, wherein the first time series data comprises:
- 30 at least one of a time that a digital pen used by the user is in contact with a floor in a pen-down state, a time that the digital pen moves from a stroke to another stroke in a pen-up state, or a distance traveled from a stroke to

another stroke while the user performs the first task of the first content.

[Claim 4]

The method of claim 1,

wherein the first structured data comprises a performance score for the first task,

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the method further comprises calculating the performance score for the first task based on the first picture information, and

the calculating of the performance score comprises:

segmenting the first picture into a plurality of areas based on the first picture information;

10

normalizing a first target symbol comprised in a first area of the plurality of areas;

determining a first performance score for the first area based on the normalized first target symbol and a first reference symbol that is preset to the first area; and

15

determining the performance score for the first task based on the first performance score.

[Claim 5]

The method of claim 4,

wherein the determining of the first performance score for the first area based on the normalized first target symbol and the first reference symbol that is preset to the first area comprises:

20

determining the first performance score by inputting the normalized first target symbol to a convolutional neural network (CNN) that is pre-updated.

[Claim 6]

The method of claim 1,

25

wherein the first structured data comprises first parameter information obtained by a digital pen that the user uses while the user performs the first task of the first content, and

the first parameter information comprises at least one of a first moving speed of the digital pen during a first time that the digital pen is in contact with a touch display of the user terminal, pen pressure during the first time, the number of strokes drawn in a preset time, or a second time that the user does not draw.

30

- [Claim 7] The method of claim 1,
 wherein the determining of the dementia degree of the user comprises:
 generating a first feature by inputting at least one of the first time series
 data and the second time series data to a pre-updated first ANN;
 5 generating a second feature by inputting at least one of the first structured
 data and the second structured data to a pre-updated second ANN;
 generating a concatenated feature by inputting the first feature and the
 second feature to an ANN-based concatenate layer; and
 determining the dementia degree of the user by inputting the
 10 concatenated feature to an ANN-based fully connected layer.
- [Claim 8] The method of claim 1, further comprising:
 outputting third content through the user terminal, wherein the third
 content instructs the user to perform a third task through a third touch
 action on the user terminal; and
 15 obtaining third reaction information of the user to the third content
 through the user terminal, wherein the third reaction information
 comprises at least one of third picture information about a third picture
 generated by the user as the first task, third time series data obtained with
 respect the third touch action, and third structured data related to the third
 20 picture.
- [Claim 9] The method of claim 1,
 wherein the dementia degree is one of normal, subjective cognitive
 impairment (SCI), mild cognitive impairment (MCI), and Alzheimer's
 disease (AD).
- 25 [Claim 10] The method of claim 1,
 wherein the determined dementia degree is output through the user
 terminal.
- [Claim 11] A non-transitory computer-readable storage medium storing a program
 to perform the method of claim 1.
- 30 [Claim 12] An electronic device for determining a dementia degree of a user, the
 electronic device comprising:
 a memory storing a program for determining a dementia degree of a user;

and

a processor configured to perform the program,

wherein the program is configured to perform:

outputting first content through a user terminal, wherein the first content
 5 instructs the user to perform a first task through a first touch action on
 the user terminal;

obtaining first reaction information of the user to the first content through
 the user terminal, wherein the first reaction information comprises at
 10 least one of first picture information about a first picture generated by the
 user as the first task, first time series data obtained with respect to the
 first touch action, and first structured data related to the first picture;

outputting second content through the user terminal, wherein the second
 content instructs the user to perform a second task through a second touch
 action on the user terminal;

15 obtaining second reaction information of the user to the second content
 through the user terminal, obtaining second reaction information of the
 user to the second content through the user terminal, wherein the second
 reaction information comprises at least one of second picture information
 about a second picture generated by the user as the second task, second
 20 time series data obtained with respect to the second touch action, and
 second structured data related to the second picture; and

determining the dementia degree of the user by inputting the first reaction
 information and the second reaction information to a dementia degree
 classification model based on an artificial neural network (ANN) for
 25 determining a dementia degree.

[Claim 13]

The electronic device of claim 12,
 wherein the first content and the second content comprise an instruction
 provided as a voice or a text to instruct an action to the user.

[Claim 14]

The electronic device of claim 12,
 30 wherein the first time series data comprises at least one of a time that a
 digital pen used by the user is in contact with a floor in a pen-down state,
 a time that the digital pen moves from a stroke to another stroke in a pen-

up state, or a distance traveled from a stroke to another stroke while the user performs the first task of the first content.

[Claim 15] The electronic device of claim 12,

wherein the determining of the dementia degree of the user comprises:

5 generating a first feature by inputting at least one of the first time series data and the second time series data to a pre-updated first ANN;

generating a second feature by inputting at least one of the first structured data and the second structured data to a pre-updated second ANN;

10 generating a concatenated feature by inputting the first feature and the second feature to an ANN-based concatenate layer; and

determining the dementia degree of the user by inputting the concatenated feature to an ANN-based fully connected layer.

15