US 20250261896A1

(19) United States
(12) Patent Application Publication
HIRSH et al.

(10) Pub. No.: US 2025/0261896 A1
(43) Pub. Date: Aug. 21, 2025

(54) **SYSTEM AND METHOD OF CREATING CURATIVE GAMES**

(71) Applicant: **EMAZELABS LTD.**, Tzur Yitzhak (IL)

(72) Inventors: **Omer HIRSH**, Tzur Yitzhak (IL); **Barak AVIV**, Tzur Yitzhak (IL)

(21) Appl. No.: **19/056,923**

(22) Filed: **Feb. 19, 2025**

Related U.S. Application Data

(60) Provisional application No. 63/555,114, filed on Feb. 19, 2024.

Publication Classification

(51) **Int. Cl.**

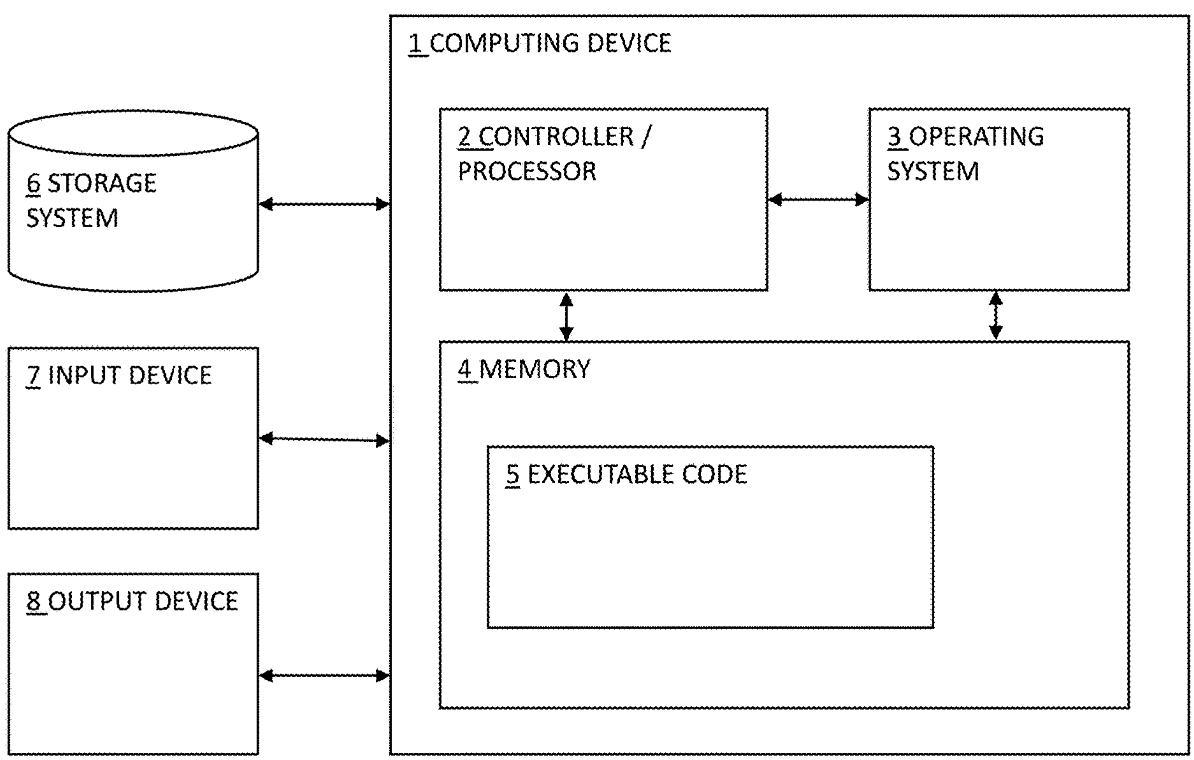
A61B 5/372	(2021.01)
A61B 5/00	(2006.01)
A61B 5/378	(2021.01)
A61B 5/38	(2021.01)
A61M 21/00	(2006.01)
G16H 10/20	(2018.01)
G16H 50/20	(2018.01)

(52) **U.S. Cl.**

CPC ***A61B 5/372*** (2021.01); ***A61B 5/378*** (2021.01); ***A61B 5/38*** (2021.01); ***A61B 5/7267*** (2013.01); ***A61M 21/00*** (2013.01); ***G16H 10/20*** (2018.01); ***G16H 50/20*** (2018.01); *A61M 2021/0027* (2013.01); *A61M 2021/0044* (2013.01); *A61M 2205/502* (2013.01); *A61M 2230/10* (2013.01)

(57) **ABSTRACT**

A system and a method of producing a curative game by at least one processor may include obtaining a brain map data structure, associating specific brain regions with respective, audiovisual stimuli; receiving an expert diagnosis of a neurological impairment of a subject; based on the expert diagnosis, prompting the subject to engage in at least one evaluation activity that corresponds to the neurological impairment, via a user interface (UI); assessing a functionality of one or more brain regions of the subject based on the evaluation activity; selecting one or more brain regions based on the assessed functionality; and creating at least one audiovisual, curative game designed to stimulate the selected brain region based on the brain map data structure.



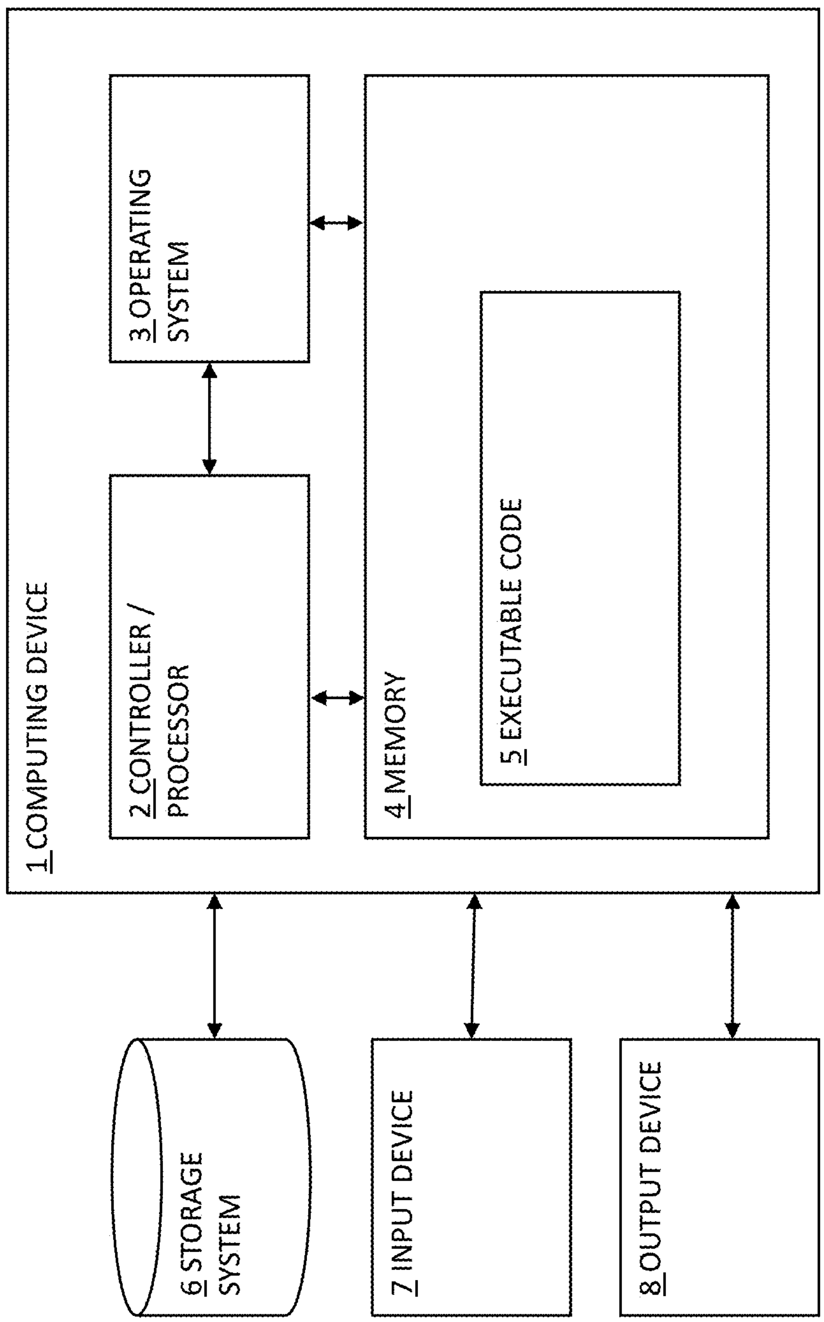

1 COMPUTING DEVICE
2 CONTROLLER / PROCESSOR
3 OPERATING SYSTEM
4 MEMORY
5 EXECUTABLE CODE
6 STORAGE SYSTEM
7 INPUT DEVICE
8 OUTPUT DEVICE

FIG. 1

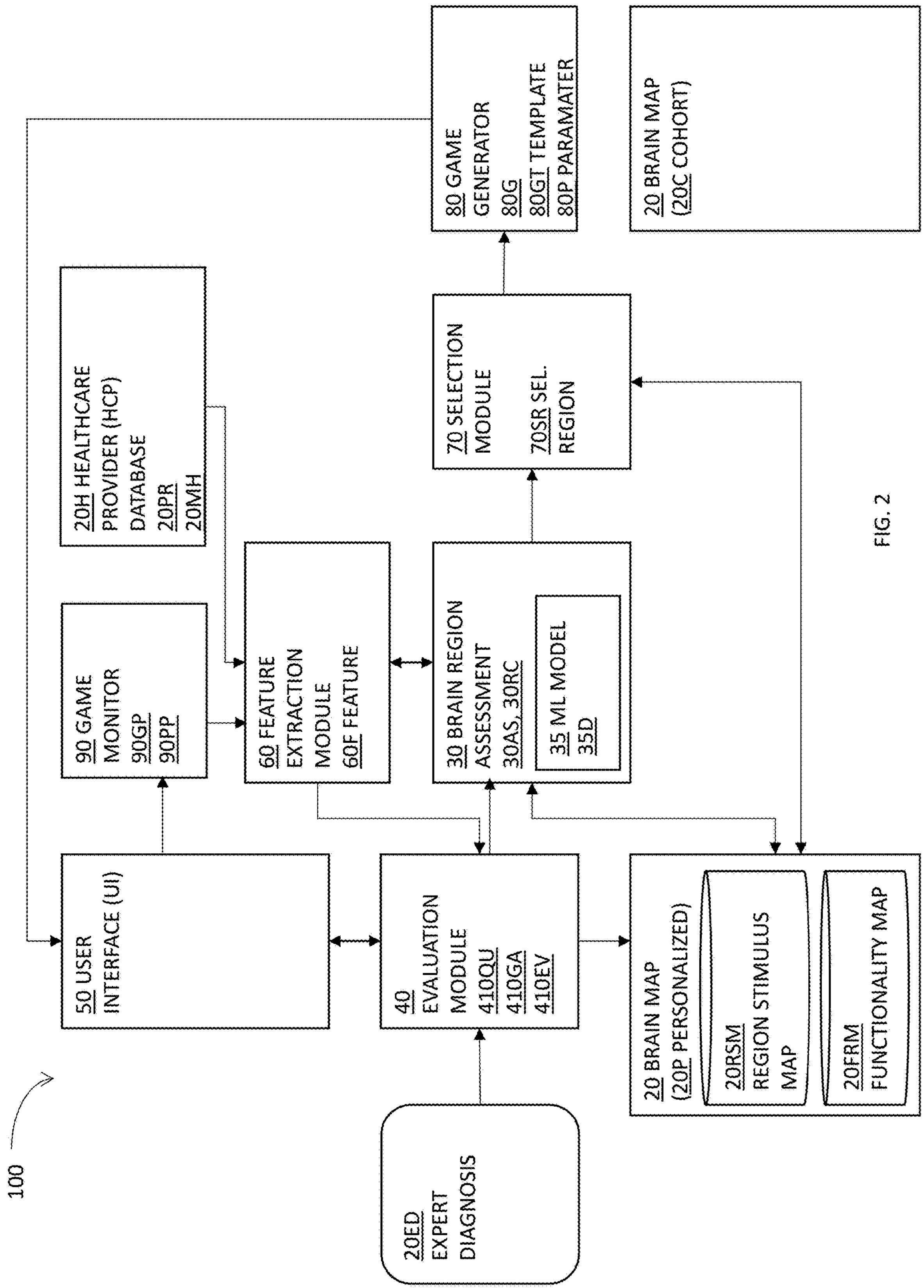
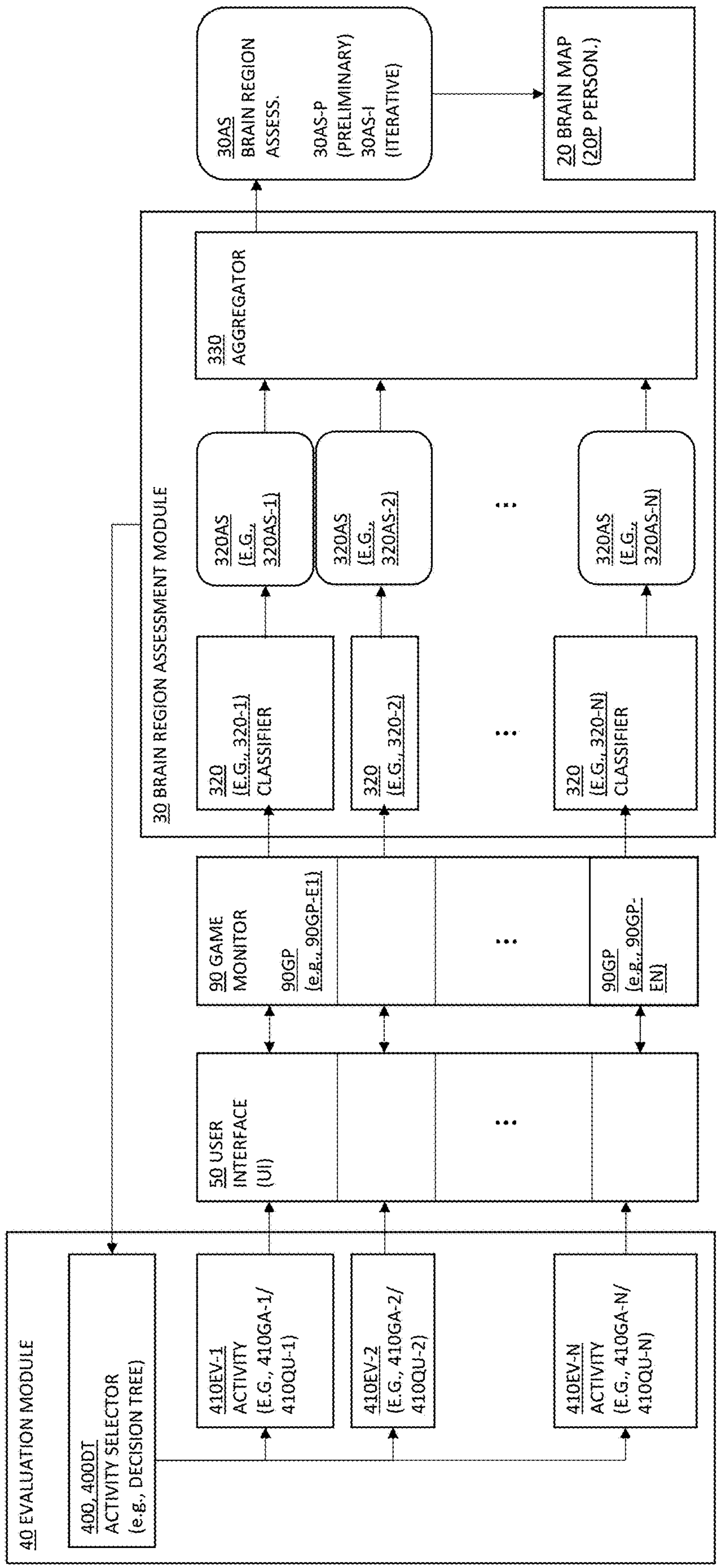

100
50 USER INTERFACE (UI)
90 GAME MONITOR
90GP
90PP
20H HEALTHCARE PROVIDER (HCP) DATABASE
20PR
20MH
60 FEATURE EXTRACTION MODULE
60F FEATURE
40 EVALUATION MODULE
410QU
410GA
410EV
30 BRAIN REGION ASSESSMENT
30AS, 30RC
35 ML MODEL
35D
70 SELECTION MODULE
70SR SEL. REGION
80 GAME GENERATOR
80G
80GT TEMPLATE
80P PARAMATER
20 BRAIN MAP (20C COHORT)
20ED EXPERT DIAGNOSIS
20 BRAIN MAP (20P PERSONALIZED)
20RSM REGION STIMULUS MAP
20FRM FUNCTIONALITY MAP

FIG. 2



40 EVALUATION MODULE
400, 400DT
ACTIVITY SELECTOR
(e.g., DECISION TREE)
410EV-1
ACTIVITY
(E.G., 410GA-1/
410QU-1)
410EV-2
(E.G., 410GA-2/
410QU-2)
410EV-N
ACTIVITY
(E.G., 410GA-N/
410QU-N)
50 USER
INTERFACE
(UI)
...
90 GAME
MONITOR
90GP
(e.g., 90GP-E1)
90GP
(e.g., 90GP-
EN)
30 BRAIN REGION ASSESSMENT MODULE
320
(E.G., 320-1)
CLASSIFIER
320
(E.G., 320-2)
320
(E.G., 320-N)
CLASSIFIER
320AS
(E.G.,
320AS-1)
320AS
(E.G.,
320AS-2)
320AS
(E.G.,
320AS-N)
330
AGGREGATOR
30AS
BRAIN REGION
ASSESS.
30AS-P
(PRELIMINARY)
30AS-I
(ITERATIVE)
20 BRAIN MAP
(20P PERSON.)

FIG. 3

20
(20FRM)

Skill	Region (lobe) weights and scores								
Focused attention	Left Dorsolateral prefrontal cortex (DLPFC) Weight: 50 30AS Score	Left Orbital frontal Weight: 50 30AS score							
Inhibition			Left Basal Ganglia Indirect Weight: 10 30AS score	Right Dorsolateral prefrontal cortex (DLPFC) Weight: 40 30AS score	Right Orbital frontal Weight: 40 30AS score				
Visual tracking						Left Parietal Weight: 30 30AS score	Left Cerebellum Weight: 20 30AS score	Right Parietal Weight: 30 30AS score	Right Cerebellum Weight: 20 30AS score

FIG. 4A

20 (20RSM)

Skill	Game parameters (80P)	Parameter(s) 80P description					
Focused attention	"bg_images_cdn_location": "games/background/texture/warm/", "main_images_cdn_location": "games/objects/eggs/", "color_scheme":"warm", "answers_location":"SE", "movement_direction":"LTR", "rotation":"counter_clockwise", "rotation_time":"10", "movement_time":"10", "movement_type":"1" "time_to_play": 60, "time_per_question": 15, "number_of_object": 3, "number_of_distractors": 3, "average_answer_time": 3000	Focused attention - Mostly a Left frontal lobe function. Left frontal lobe is activated by the right cerebellum among other things. This game may stimulate the left frontal lobe and/or the right cerebellum. This game may also stimulate the left Parietal lobe to support the part of the frontal lobe called the dorsolateral prefrontal cortex (DLPFC)	Textured: more parietal lobe, more dorsolateral prefrontal cortex.	Warm background: left brain	SE: Objects will be mostly positioned in the "Southeast" (SE) quadrant. E=Right field of view goes to the left brain. S=Bottom field of view processed more in the parietal lobe	LTR = left to right eye movement. Combined with movement type "1" = saccades (eye jumps), will activate more the frontal eye fields on the left and the right cerebellum.	Counter-clockwise rotation - will simulate turning the head in the opposite direction, stimulating the right vestibullar system, the right cerebellum and so the left frontal lobe.
Inhibition	"bg_images_cdn_location": "games/background/texture/cold/", "main_images_cdn_location": "games/objects/cubes/", "color_scheme":"cold", "answers_location":"SW", "movement_direction":"RTL", "rotation":"clockwise", "rotation_time":"10", "movement_time":"10", "movement_type":"1" "time_to_play": 60, "time_per_question": 15, "number_of_object": 3, "number_of_distractors": 3, "average_answer_time": 3000	Inhibition is mostly a function of the indirect pathway of the basal ganglia, which is moslty driven by the right frontal lobes. These in turn are driven by the left cerebellum, and by information coming into the parietal and temporal lobes going to the orbital frontal prefrontal and dorsolateral prefrontal cortex regions.	Textured = more parietal lobe, more dorsolateral prefrontal cortex.	Cold Background: right brain	NW: Objects will be mostly positioned in the - "Northwest" (NW) quadrant, W=left field of view goes to the right brain. N=Top field of view processed in the parietal lobe	RTL = Right to Left eye movement. Combined with movement type "1" = saccades (eye jumps), will activate more the frontal eye fields on the right and the left cerebellum.	Clockwise rotation - will simulate turning the head in the opposite direction, stimulating the left vestibullar system, the left cerebellum and so the right frontal lobe.

FIG. 4B

#	Brain region classifier (35ML)	Game description (parameters 80P)	Measured reaction (90GP)
1	Cerebellum Frontal lobes Brainstem (Pons/Mesencephalon)	Move Right/Left Move Up/Down Obstacles (Right/Left) Target Placing (Right/Left)	Reaction time Accuracy Timing Success rate
2	Parietal Temporal Brainstem (Pons/Mesencephalon) Cerebellum	Solid/textured Move Right/Left Obstacles (Up/Down) Target Placing (Up/Dn)	Reaction time Accuracy Timing Success rate
3	Prefrontal Parietal/Temporal Cerebellum	Movement smooth/jumps Target Placing (Right/Left) Obstacles (Up/Down) Target Placing (Up/Dn)	Unnecesary clicks Missing clicks Timing Success rate
4	Basal Ganglia Direct Basal Ganglia Indirect Cerebellum Prefrontal	Distractors (auditory/visual) Movement (yes/no) Obstacles (Right/Left) Target Placing (Right/Left)	Unnecessary clicks Missing clicks Early clicks Late clicks Timing

FIG. 5

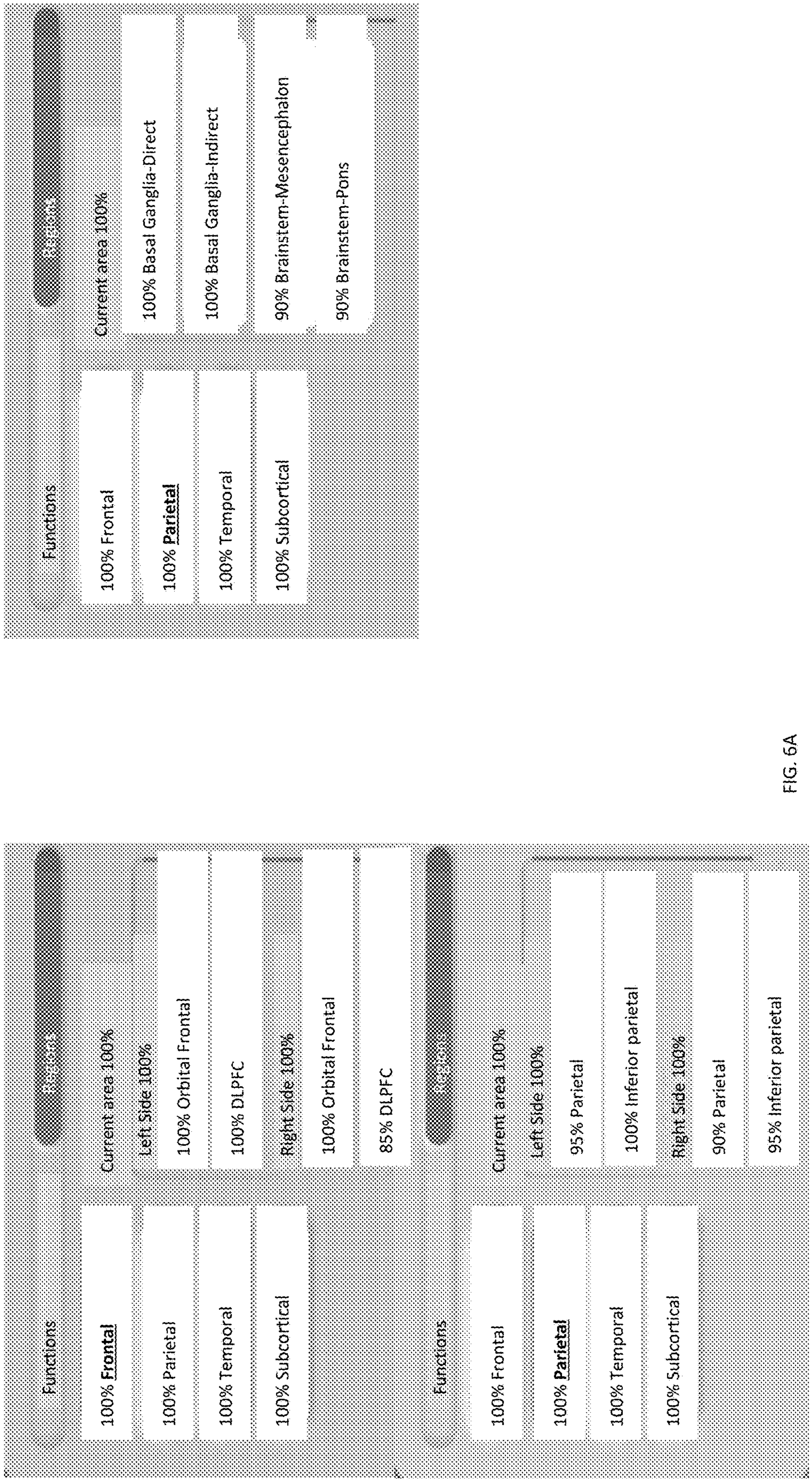

Functions
100% Frontal
100% Parietal
100% Temporal
100% Subcortical
Regions
Current area 100%
100% Basal Ganglia-Direct
100% Basal Ganglia-Indirect
90% Brainstem-Mesencephalon
90% Brainstem-Pons
Functions
100% Frontal
100% Parietal
100% Temporal
100% Subcortical
Regions
Current area 100%
Left Side 100%
100% Orbital Frontal
100% DLPFC
Right Side 100%
100% Orbital Frontal
85% DLPFC
Functions
100% Frontal
100% Parietal
100% Temporal
100% Subcortical
Regions
Current area 100%
Left Side 100%
95% Parietal
100% Inferior parietal
Right Side 100%
90% Parietal
95% Inferior parietal

FIG. 6A

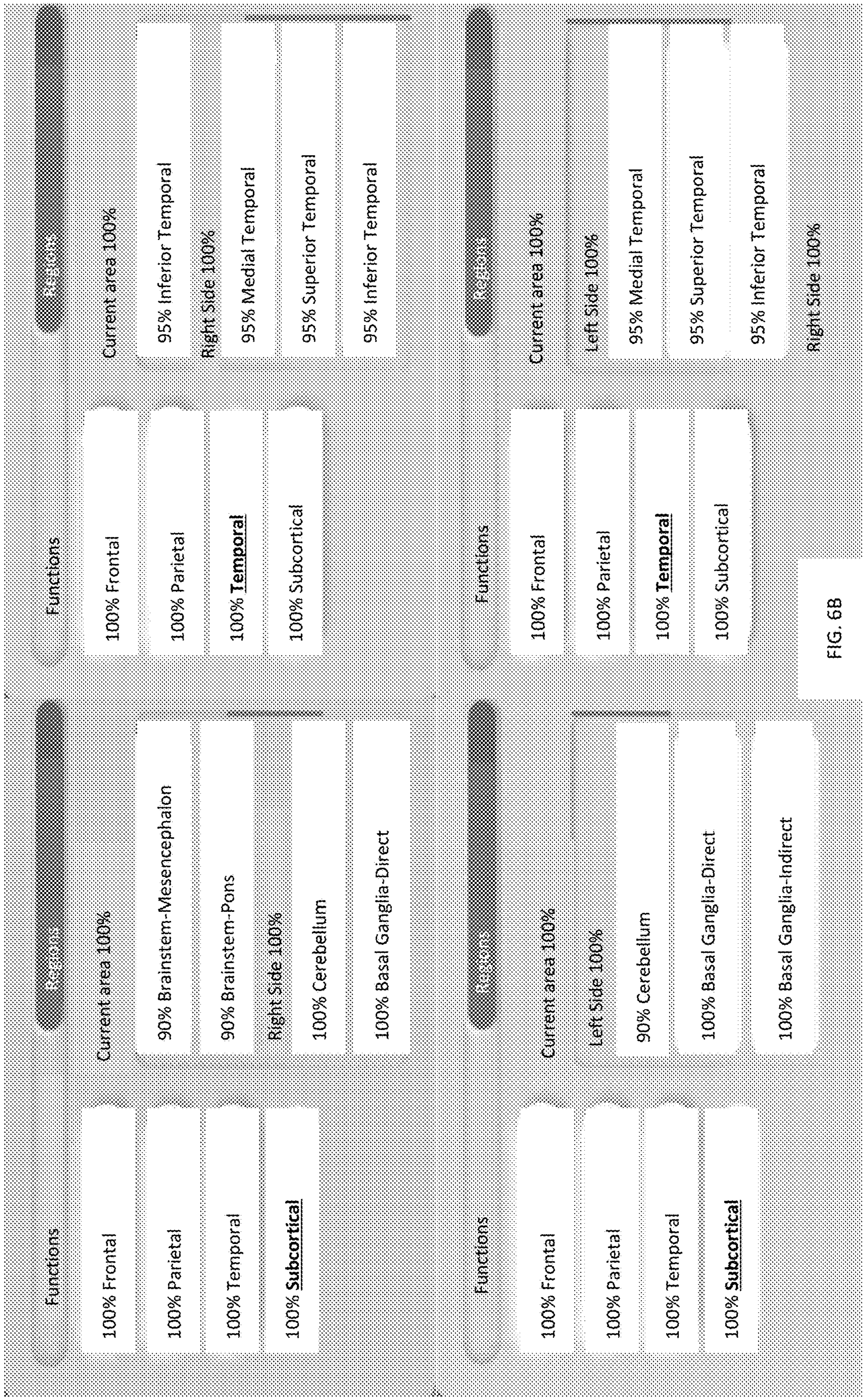

Functions
100% Frontal
100% Parietal
100% Temporal
100% **Subcortical**
Regions
Current area 100%
90% Brainstem-Mesencephalon
90% Brainstem-Pons
Right Side 100%
100% Cerebellum
100% Basal Ganglia-Direct
Functions
100% Frontal
100% Parietal
100% **Temporal**
100% Subcortical
Regions
Current area 100%
95% Inferior Temporal
Right Side 100%
95% Medial Temporal
95% Superior Temporal
95% Inferior Temporal
Functions
100% Frontal
100% Parietal
100% Temporal
100% **Subcortical**
Regions
Current area 100%
Left Side 100%
90% Cerebellum
100% Basal Ganglia-Direct
100% Basal Ganglia-Indirect
Functions
100% Frontal
100% Parietal
100% **Temporal**
100% Subcortical
Regions
Current area 100%
Left Side 100%
95% Medial Temporal
95% Superior Temporal
95% Inferior Temporal
Right Side 100%

FIG. 6B

S1005 OBTAINING A BRAIN MAP DATA STRUCTURE, ASSOCIATING SPECIFIC BRAIN REGIONS WITH RESPECTIVE, AUDIOVISUAL STIMULI.

S1010 RECEIVING AN EXPERT DIAGNOSIS OF A NEUROLOGICAL IMPAIRMENT OF A SUBJECT.

S1015 BASED ON THE EXPERT DIAGNOSIS, PROMPTING THE SUBJECT TO ENGAGE IN AT LEAST ONE EVALUATION ACTIVITY THAT CORRESPONDS TO THE NEUROLOGICAL IMPAIRMENT, VIA A UI.

S1020 ASSESSING A FUNCTIONALITY OF ONE OR MORE BRAIN REGIONS OF THE SUBJECT BASED ON THE EVALUATION ACTIVITY.

S1025 SELECTING ONE OR MORE BRAIN REGIONS BASED ON THE ASSESSED FUNCTIONALITY. AND

S1030 CREATING AT LEAST ONE AUDIOVISUAL, CURATIVE GAME DESIGNED TO STIMULATE THE SELECTED BRAIN REGION BASED ON THE BRAIN MAP DATA STRUCTURE.

FIG. 7

SYSTEM AND METHOD OF CREATING CURATIVE GAMES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Patent Application No. 63/555,114, filed Feb. 19, 2024, and titled "SYSTEM AND METHOD OF CREATING CURATIVE GAMES", which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates generally to the technological field of assistive diagnostics treatment. More specifically, the present invention relates to systems and methods of creating curative games, for diagnosing and treating neurological impairments.

BACKGROUND OF THE INVENTION

[0003] Neurological impairments, encompassing a spectrum of disorders affecting various regions of the brain, impose significant challenges on affected individuals and their families. With a growing prevalence globally, driven by various factors including lifestyle changes and environmental influences, these conditions lead to diminished quality of life, and socioeconomic burdens. Challenges in accurately diagnosing and effectively treating neurological impairments, especially in children, persist despite advances in medical science. Innovative approaches are needed to improve early detection, personalize treatment strategies, and enhance patient outcomes.

SUMMARY OF THE INVENTION

[0004] As elaborated herein, embodiments of the invention may include a method and system for producing curatives game based on an iterative, rehabilitative neuroplastic process.

[0005] Embodiments of the invention may include a method of producing a curative game by at least one processor. According to some embodiments, the at least one processor may be configured to obtain a brain map data structure, associating specific brain regions with respective, audiovisual stimuli; receive an expert diagnosis of a neurological impairment of a subject; based on the expert diagnosis, prompt the subject to engage in at least one evaluation activity that corresponds to the neurological impairment, via a user interface (UI); assess, or calculate a functionality of one or more brain regions of the subject based on the evaluation activity; select one or more brain regions based on the assessed functionality; and create at least one audiovisual, curative game designed to stimulate the selected brain region based on the brain map data structure.

[0006] According to some embodiments, the at least one processor may prompt the subject to engage in an evaluation activity by presenting a questionnaire to the subject via the UI; obtaining the subject's response to the questionnaire via the UI; assessing the functionality of the one or more brain regions of the subject based on the subject's response; and personalizing the brain map to reflect the assessed functionality of one or more brain regions of the subject.

[0007] According to some embodiments, the at least one processor may assess the brain functionality of the one or more brain regions in an iterative process. Each iteration of this process may include prompting the subject to engage in an evaluation activity; assessing a functionality of one or more brain regions of the subject based on outcome of the evaluation activity; updating the brain map data structure, based on the assessed functionality, thereby producing a personalized brain map data structure; and employing a decision tree, to select an evaluation activity for a subsequent iteration, based on the personalized brain map data structure.

[0008] Additionally, or alternatively, the at least one processor may be configured to prompt the subject to engage in an evaluation activity by presenting evaluation game to the subject via the UI; monitoring the subject's playing, to extract a value of at least one evaluation game performance parameter; assessing the functionality of the one or more brain regions of the subject based on the at least one evaluation game performance parameter; and personalizing the brain map to reflect the assessed functionality of one or more brain regions of the subject.

[0009] According to some embodiments, the at least one processor may create a curative game by selecting, from a pool of game templates, a game template that corresponds to the neurological impairment; and adapting at least one game parameter of the selected game template, so as to stimulate the selected brain region, based on the brain map data structure.

[0010] According to some embodiments, the at least one processor may create the curative game by an iterative process. Each iteration of the iterative process may include prompting the subject to play (e.g., via the UI) one or more iterations of at least one created game; monitoring the subject's playing, to extract a value of at least one game performance parameter in the one or more iterations; analyzing the game performance parameter values, to identify suboptimal functionality of the one or more selected brain regions; and updating the brain map data structure to reflect the identified suboptimal functionality of the one or more selected brain regions.

[0011] According to some embodiments, the at least one processor may identify suboptimal functionality of one or more brain regions of the subject (e.g., human patient) by determining a rate of change, across the one or more iterations, of function of a specific region of the one or more selected brain regions; and analyzing, or comparing the determined rate of change in view of a predetermined baseline rate of expected change, to identify the suboptimal functionality.

[0012] Additionally, or alternatively, the at least one processor may train, or obtain a pretrained machine learning (ML) based model; and infer the ML based model on (i) the one or more game performance parameters, and (ii) the expert diagnosis, to predict a refined diagnosis of the neurological impairment of the subject.

[0013] According to some embodiments, the predicted refined diagnosis may include, for example an identification, or prediction of a suboptimal functionality of one or more brain regions of the subject; an assessment (e.g., a score), representing functionality of a specific, associated brain region; a subclass or an evaluation of a severity of the diagnosed neurological impairment; a refined version of a functional region map and/or a refined version of a region stimulus map of the subject; a prognosis, or an expected change in the neurological impairment condition of the subject; a recommended treatment, such as a game template to be used with the subject, and the like.

[0014] Additionally, or alternatively, the at least one processor may train, or obtain a pretrained ML based model; infer the ML based model on the one or more game performance parameters, to predict suboptimal functionality of at least one brain region of the subject; and update the brain map data structure to reflect the predicted suboptimal functionality of the at least one brain region.

[0015] Additionally, or alternatively, the at least one processor may adjust at least one game parameter of the created game based on the brain map data structure, so as to stimulate the selected brain region of the identified suboptimal functionality.

[0016] Additionally, or alternatively, the at least one processor may select, from a pool of game templates, a specific game template that corresponds to the neurological impairment; and adapt at least one game parameter of the selected game template based on the brain map data structure, so as to stimulate the selected brain region of the identified suboptimal functionality.

[0017] Additionally, or alternatively, the at least one processor may determine a rate of change across the one or more iterations, of functionality of a specific region of the one or more selected brain regions; and infer an ML-based model on (i) the determined rate of change, and (ii) the expert diagnosis, to predict a refined diagnosis of the neurological impairment of the subject.

[0018] Additionally, or alternatively, the at least one processor may create the curative game by obtaining, or calculating at least one profile data element, representing a profile of the subject; obtaining, or calculating at least one medical data element, representing a medical history of the subject; and adapting a game parameter of the selected game template based on the at least one profile data elements and the at least one medical data element, so as to stimulate the selected brain region, according to the brain map data structure.

[0019] Embodiments of the invention may include a system for treating a neurological impairment of a subject. Embodiments of the system may include a non-transitory memory device, wherein modules of instruction code are stored, and at least one processor associated with the memory device, and configured to execute the modules of instruction code.

[0020] Upon execution of the modules of instruction code, the at least one processor may be configured to: obtain a brain map data structure, associating specific brain regions with respective, audiovisual stimuli; receive an expert diagnosis of a neurological impairment of a subject; based on the expert diagnosis, prompt the subject to engage in at least one evaluation activity that corresponds to the neurological impairment, via a UI; based on the evaluation, produce an assessment of functionality of one or more brain regions of the subject; select one or more brain regions based on said assessment; create at least one audiovisual, curative game designed to stimulate the selected brain region based on the brain map data structure; and prompt the subject to play the created game via the UI.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The subject matter regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, together with objects, features, and advantages thereof, may best be understood by reference to the following detailed description when read with the accompanying drawings in which:

[0022] FIG. **1** is a block diagram, depicting a computing device which may be included in a system for creating curative games for diagnosing and treating neurological impairments, according to some embodiments;

[0023] FIG. **2** is a block diagram, depicting a system for creating curative games according to some embodiments of the invention;

[0024] FIG. **3** is a block diagram, elaborating aspects of functionality of the system for creating curative games, according to some embodiments of the invention;

[0025] FIG. **4**A and **4**B are tables elaborating aspects of a brain map data structure, according to some embodiments of the invention;

[0026] FIG. **5** is a table elaborating examples of brain region-specific classifiers which may be included in some embodiments of the invention;

[0027] FIGS. **6**A and **6**B present data that may be accumulated from a subject, representing one use case of an embodiment of the invention; and

[0028] FIG. **7** is a flow diagram, depicting a method of creating curative games according to some embodiments of the invention.

[0029] It will be appreciated that for simplicity and clarity of illustration, elements shown in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements may be exaggerated relative to other elements for clarity. Further, where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0030] One skilled in the art will realize the invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The foregoing embodiments are therefore to be considered in all respects illustrative rather than limiting of the invention described herein. Scope of the invention is thus indicated by the appended claims, rather than by the foregoing description, and all changes that come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

[0031] In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, and components have not been described in detail so as not to obscure the present invention. Some features or elements described with respect to one embodiment may be combined with features or elements described with respect to other embodiments. For the sake of clarity, discussion of same or similar features or elements may not be repeated.

[0032] Although embodiments of the invention are not limited in this regard, discussions utilizing terms such as, for example, “processing,” “computing,” “calculating,” “determining,” “establishing”, “analyzing”, “checking”, or the like, may refer to operation(s) and/or process(es) of a computer, a computing platform, a computing system, or other electronic computing device, that manipulates and/or transforms data represented as physical (e.g., electronic) quantities within the computer's registers and/or memories into other data similarly represented as physical quantities within the computer's registers and/or memories or other information non-transitory storage medium that may store instructions to perform operations and/or processes.

[0033] Although embodiments of the invention are not limited in this regard, the terms "plurality" and "a plurality" as used herein may include, for example, "multiple" or "two or more". The terms "plurality" or "a plurality" may be used throughout the specification to describe two or more components, devices, elements, units, parameters, or the like. The term "set" when used herein may include one or more items.

[0034] Unless explicitly stated, the method embodiments described herein are not constrained to a particular order or sequence. Additionally, some of the described method embodiments or elements thereof can occur or be performed simultaneously, at the same point in time, or concurrently.

[0035] Reference is now made to FIG. **1**, which is a block diagram depicting a computing device, which may be included within an embodiment of a system for creating curative games for diagnosing and treating neurological impairments, according to some embodiments.

[0036] Computing device **1** may include a processor or controller **2** that may be, for example, a central processing unit (CPU) processor, a chip or any suitable computing or computational device, an operating system **3**, a memory **4**, executable code **5**, a storage system **6**, input devices **7** and output devices **8**. Processor **2** (or one or more controllers or processors, possibly across multiple units or devices) may be configured to carry out methods described herein, and/or to execute or act as the various modules, units, etc. More than one computing device **1** may be included in, and one or more computing devices **1** may act as the components of, a system according to embodiments of the invention.

[0037] Operating system **3** may be or may include any code segment (e.g., one similar to executable code **5** described herein) designed and/or configured to perform tasks involving coordination, scheduling, arbitration, supervising, controlling or otherwise managing operation of computing device **1**, for example, scheduling execution of software programs or tasks or enabling software programs or other modules or units to communicate. Operating system **3** may be a commercial operating system. It will be noted that an operating system **3** may be an optional component, e.g., in some embodiments, a system may include a computing device that does not require or include an operating system **3**.

[0038] Memory **4** may be or may include, for example, a Random-Access Memory (RAM), a read only memory (ROM), a Dynamic RAM (DRAM), a Synchronous DRAM (SD-RAM), a double data rate (DDR) memory chip, a Flash memory, a volatile memory, a non-volatile memory, a cache memory, a buffer, a short term memory unit, a long term memory unit, or other suitable memory units or storage units. Memory **4** may be or may include a plurality of possibly different memory units. Memory **4** may be a computer or processor non-transitory readable medium, or a computer non-transitory storage medium, e.g., a RAM. In one embodiment, a non-transitory storage medium such as memory **4**, a hard disk drive, another storage device, etc. may store instructions or code which when executed by a processor may cause the processor to carry out methods as described herein.

[0039] Executable code **5** may be any executable code, e.g., an application, a program, a process, task, or script. Executable code **5** may be executed by processor or controller **2** possibly under control of operating system **3**. For example, executable code **5** may be an application that may create curative games as further described herein. Although, for the sake of clarity, a single item of executable code **5** is shown in FIG. **1**, a system according to some embodiments of the invention may include a plurality of executable code segments similar to executable code **5** that may be loaded into memory **4** and cause processor **2** to carry out methods described herein.

[0040] Storage system **6** may be or may include, for example, a flash memory as known in the art, a memory that is internal to, or embedded in, a micro controller or chip as known in the art, a hard disk drive, a CD-Recordable (CD-R) drive, a Blu-ray disk (BD), a universal serial bus (USB) device or other suitable removable and/or fixed storage unit. Data pertaining to a human subject or patient may be stored in storage system **6** and may be loaded from storage system **6** into memory **4** where it may be processed by processor or controller **2**. In some embodiments, some of the components shown in FIG. **1** may be omitted. For example, memory **4** may be a non-volatile memory having the storage capacity of storage system **6**. Accordingly, although shown as a separate component, storage system **6** may be embedded or included in memory **4**.

[0041] Input devices **7** may be or may include any suitable input devices, components, or systems, e.g., a detachable keyboard or keypad, a mouse and the like. Output devices **8** may include one or more (possibly detachable) displays or monitors, speakers and/or any other suitable output devices. Any applicable input/output (I/O) devices may be connected to Computing device **1** as shown by blocks **7** and **8**. For example, a wired or wireless network interface card (NIC), a universal serial bus (USB) device or external hard drive may be included in input devices **7** and/or output devices **8**. It will be recognized that any suitable number of input devices **7** and output device **8** may be operatively connected to Computing device **1** as shown by blocks **7** and **8**.

[0042] A system according to some embodiments of the invention may include components such as, but not limited to, a plurality of central processing units (CPU) or any other suitable multi-purpose or specific processors or controllers (e.g., similar to element **2**), a plurality of input units, a plurality of output units, a plurality of memory units, and a plurality of storage units.

[0043] The term neural network (NN) or artificial neural network (ANN), e.g., a neural network implementing a machine learning (ML) or artificial intelligence (AI) function, may be used herein to refer to an information processing paradigm that may include nodes, referred to as neurons, organized into layers, with links between the neurons. The links may transfer signals between neurons and may be associated with weights. A NN may be configured or trained for a specific task, e.g., pattern recognition or classification. Training a NN for the specific task may involve adjusting these weights based on examples. Each neuron of an intermediate or last layer may receive an input signal, e.g., a weighted sum of output signals from other neurons, and may process the input signal using a linear or nonlinear function (e.g., an activation function). The results of the input and intermediate layers may be transferred to other neurons and the results of the output layer may be provided as the output of the NN. Typically, the neurons and links within a NN are represented by mathematical constructs, such as activation functions and matrices of data elements and weights. At least one processor (e.g., processor **2** of FIG. **1**) such as one or more CPUs or graphics processing units (GPUs), or a dedicated hardware device may perform the relevant calculations.

[0044] Reference is now made to FIG. **2**, which depicts a system **100** for creating curative games, for diagnosing and treating neurological impairments, according to some embodiments. Reference is also made to FIG. **3**, which shows aspects of functionality of system **100**, according to some embodiments of the invention.

[0045] According to some embodiments of the invention, system **100** may be implemented as a software module, a hardware module, or any combination thereof. For example, system **100** may be or may include a computing device such as element **1** of FIG. **1**, and may be adapted to execute one or more modules of executable code (e.g., element **5** of FIG. **1**) to create curative games as further described herein.

[0046] As shown in FIG. **2**, arrows may represent flow of one or more data elements to and from system **100** and/or among modules or elements of system **100**. Some arrows have been omitted in FIG. **2** for the purpose of clarity.

[0047] As shown in FIG. **2**, system **100** may receive, e.g., from at least one computing device or database, a brain map data structure **20**. According to some embodiments, brain map data structure **20** (or "brain map **20**", for short) may include one or more data structures such as tables or maps, that may associate specific brain regions with respective, audiovisual stimuli and/or high-level functionality.

[0048] Reference also made to FIGS. **4**A and **4**B which are tables elaborating aspects of a brain map data structure **20**, according to some embodiments of the invention.

[0049] According to some embodiments, brain map **20** may include, or be arranged as a functional region map data structure **20**FRM that may associate between specific high-level functions (e.g., reading) and specific, respective regions in the brain that are incorporated in that functionality (in this example, the left hemisphere frontal, temporal and parietal regions).

[0050] Additionally, or alternatively, functional region map data structure **20**FRM may indicate an extent, or weight (e.g., in time and space) of participation of specific brain regions in a high-level function or task.

[0051] Pertaining to the example of FIG. **4**A, the task of focused attention may be weighted, or divided in a ratio of [50:50] between the Left Dorsolateral prefrontal cortex (DLPFC) and Left Orbital Frontal (LOF) lobe.

[0052] In another example, the task of inhibition may be weighted, or divided in a ratio of [10:40:40:10] between the Left Basal Ganglia Indirect, the Right DLPFC, the Right Orbital frontal lobe, and the Right Basal Ganglia Indirect.

[0053] In yet another example, the task of visual tracking may be weighed, or divided at a ratio of [30:20:30:20] between the Left Parietal lobe, Left Cerebellum Right Parietal lobe and Right Cerebellum lobes.

[0054] Additionally, or alternatively, brain map **20** may include a Region Stimulus Map (RSM) **20**RSM, that may associate specific brain regions with respective, audiovisual stimuli. In other words, region stimulus map **20**RSM may indicate amplitude and/or extent (e.g., in time and space) of an effect of a specific stimulus (e.g., image and/or audio) that may be presented to a subject via a User Interface (UI) **50** (such as devices **7**, **8** of FIG. **1**), on specific brain regions of the subject.

[0055] Pertaining to the example of FIG. **4**B, in order to evaluate a specific skill or task, region stimulus map **20**RSM of brain map **20** may associate this skill with a list of predetermined game parameter **80**P values. The list of game parameter values **80**P may be designed to stimulate the brain regions associated with the specific task or activity.

[0056] For example, to evaluate a skill of focused attention, brain map **20** (**20**RSM) may specify values of game parameters **80**P such as a texture (adapted to stimulate the parietal lobe and dorsolateral prefrontal cortex), a background colour (warm background stimulating the left hemisphere), a type of movement of presented objects (left to right saccadic movement to stimulate the left and right Cerebellum), position of presented objects ("Southeast" (SE) quadrant, to stimulate the left Parietal lobe), and the like.

[0057] It may be appreciated that the examples provided in FIGS. **4**A and **4**B are brought for clarification, and are neither limiting, nor exhaustive. Both parts of brain map **20**, e.g., functional region map data structure **20**FRM and region stimulus map **20**RSM, may include additional entries, pertaining to additional cognitive functionalities and additional brain regions.

[0058] As shown in FIG. **2**, system **100** may receive, e.g., via input device **7** of FIG. **1** an expert diagnosis **20**ED of a neurological impairment of a subject. For example, expert diagnosis **20**ED may include indication of a cognitive or behavioural neurological impairment, such as Attention-Deficit/Hyperactivity Disorder (ADHD), Autistic Spectrum Disorder (ASD), Dyslexia, Sensory Processing Disorder (SPD), and the like.

[0059] In another example, expert diagnosis **20**ED may include indication of a motoric neurological impairment, such as Dysgraphia, Developmental Coordination Disorder (DCD), stuttering, and the like.

[0060] As shown in FIG. **2**, system **100** may include an initial evaluation module **40** (or "evaluation module **40**", for short). According to some embodiments, initial evaluation module **40** may be configured to prompt the subject to engage, e.g., via UI **50** in at least one evaluation activity **410**EV. Evaluation activity **410**EV may correspond to one or more specific neurological impairments based on, or expressed by the initial expert diagnosis **20**ED.

[0061] Initial expert diagnosis **20**ED may include an indication of neurological impairment such as a reading disability (e.g., developmental dyslexia, acquired dyslexia, hyperlexia, etc.) of a specific subject. Initial evaluation module **40** may adapt, or select evaluation activity **410**EV to evaluate specific, personal characteristics of that subject according to initial expert diagnosis **20**ED.

[0062] As elaborated herein, evaluation module **40** may produce an evaluation activity **410**EV that includes one or more questionnaires **410**QU (denoted **410**QU-**1**, . . . , **410**QU-N) or forms. Questionnaires **410**QU may be adapted to obtain parameters or characteristics describing the subject's neurological impairment. Evaluation module **40** may present evaluation activity **410**EV (e.g., questionnaire **410**QU) via UI **50**, to obtain the subject's response to the questionnaire via UI **50**. The subject's response may include, for example structured, or semi-structured data representing the subject's personal characteristics of the neurological impairment included in the initial expert diagnosis **20**ED.

[0063] In another example, evaluation module **40** may produce an evaluation activity **410**EV that includes one or more evaluation games **410**GA (denoted **410**GA-**1**, . . . , **410**GA-N), adapted to evaluate the subject's characteristics of the specific neurological impairment.

[0064] Evaluation module **40** may present evaluation activity **410**EV (e.g., evaluation game(s) **410**GA) via UI **50** to the subject. Evaluation module **40** may collaborate with a monitoring module **90**, configured to monitor the subject's activity (e.g., playing), to extract a value of at least one respective evaluation game performance parameter **90**GP (denoted **90**GP-E**1**, . . . , **90**GP-EN), representing for example, the subject's response time, success rate, overall success or failure, and the like, as elaborated herein.

[0065] Evaluation module **40** may collaborate with a brain assessment module **30**, adapted to assess the functionality of the one or more brain regions of the subject, based on outcome of the one or more evaluation activities **410**EV (e.g., the subject's response to questionnaire(s) **410**QU-**1**, . . . , **410**QU-N) and/or evaluation game performance parameter **90**GP (denoted **90**GP-E**1**, . . . , **90**GP-EN). As elaborated herein, Brain assessment module **30** may assess the functionality of the one or more brain regions based on evaluation activity.

[0066] According to some embodiments, brain assessment module **30** may calculate an assessment **30**AS representing overall severity of the subject's underlying neurological impairment, based on brain map data structure **20**. This assessment of brain region functionality may be performed iteratively, e.g., by a cascade of classifier modules **320** (e.g., **320**-**1**, . . . , **320**-N). Each iteration may include (a) selection of an evaluation activity **410**EV by an activity selection module **400**, (b) assessing (e.g., **320**AS-**1**, **320**AS-**2**, etc.) functionality of an interim subset of brain regions by a respective classifier **320**, and (c) prompting the subject to engage in a subsequent evaluation activity **410**EV, based on the results of the current iteration.

[0067] Additionally, or alternatively, assessment module **30** may update the brain map data structure **20** (e.g., **20**FRM), based on (e.g., to include) the assessed functionality scores **320**AS, thereby personalizing an interim version of brain map data structure **20**, according to the underlying diagnosed impairment **20**ED. In a subsequent iteration, system **100** may prompt the subject to engage in a subsequent evaluation activity **410**EV, based on the personalized brain map data structure.

[0068] The iterative assessment process may end by aggregating assessment results or scores **320**AS (e.g., **320**AS-**1**, . . . , **320**AS-N), thereby providing an overall assessment **30**AS of brain regions.

[0069] Additionally, or alternatively, the iterative assessment process may end with updating brain map **20** (**20**FRM) to reflect, or include assessment scores **30**AS, as shown in FIG. **4**A, thereby producing an initial baseline (e.g., prior to treatment), personalized, brain map **20**, representing functionality of brain regions of the specific subject.

[0070] Reference is now made to FIG. **5**, which is a table elaborating examples of brain region-specific classifiers **320**, which may be included in some embodiments of the invention. As shown in this example, each brain region-specific classifier **320** may be associated with respective game parameters **80**P, specifically selected to stimulate the respective brain region, as elaborated herein. Additionally, each brain region-specific classifier **320** may be associated with respective reaction measurements **90**GP, that correspond to activities **410**EV. Reaction measurements **90**GP have been experimentally found to be prominent in the assessment or score **30**AS of the respective brain region functionality.

[0071] For example, a subject's neurological impairment may be a reading impairment, such as dyslexia. As known in the art, a skill that is required for reading includes the ability to perform visual tracking. As shown in FIG. **4**A, and based on brain map data structure **20**, this ability is governed by the left and right Parietal lobes, as well as the left and right Cerebellum.

[0072] As shown in FIG. **5**, activity selection module **400** may therefore select a first activity **410**EV (e.g., evaluation game **410**GA-**1**) such as game #**4**, that is adapted to stimulate, and assess a first subset of brain regions (e.g., the Cerebellum, but not the Parietal lobes), and then proceed to a second activity **410**EV (e.g., evaluation game **410**GA-**2**) such as game #**1**, that is adapted to stimulate, and assess a second subset of brain regions (e.g., the Cerebellum, and the Parietal lobes).

[0073] During the first game **410**GA-**1** (#**4**), a first set of game parameters **80**P may be applied (e.g., using auditory and visual distractors), and a first set of user reactions may be measured or counted (e.g., counting unnecessary mouse-clicks missing mouse-clicks and early (premature) mouse-clicks), to calculate score **320**AS (e.g., higher score **320**AS when there are less unnecessary or premature mouse clicks).

[0074] During the second game **410**GA-**2** (#**1**), a second set of game parameters **80**P (e.g., moving a target up and down) may be applied, and a second set of user reactions may be measured (e.g., reaction time, hit-accuracy and overall target-hit success rate), to calculate score **320**AS (e.g., higher score for **320**AS) for lower reaction time.

[0075] As explained herein, each activity **410**EV may stimulate multiple brain regions. Activity selection module **400** may therefore employ at least one rule-based decision tree **400**DT, that may allow separation of functionality assessment to individual brain regions.

[0076] In other words, decision tree **400**DT may pertain to a specific, underlying, expert-diagnosed impairment **20**ED. Decision tree **400**DT may be specifically configured to select evaluation activities (i) hierarchically, according to brain region significance, to allow efficient analysis using a minimal number of games or sessions, and (ii) have low correlation between their respectively stimulated brain regions, to allow the required separation of region-specific assessment scores **320**AS.

[0077] As explained herein, brain assessment module **30** may calculate an assessment or score **30**AS for functionality of one or more (e.g., each) brain region that is associated with the underlying neurological impairment, in accordance with brain map data structure **20**. Brain assessment module **30** may subsequently personalize the brain map data structure **20** of a specific subject to reflect the assessed functionality of one or more brain regions of that subject, as shown in FIG. **4**A.

[0078] Pertaining to the example of FIG. **4**A, initial expert diagnosis **20**ED may include indication of a focused attention impediment in a subject. Brain assessment module **30** may analyze performance **90**GP of the subject in playing a game **410**GA that is specifically designed to evaluate the subject's focused attention. Brain assessment module **30** may thereby assess scores **30**AS of specific regions in the subject's brain (Left DLPFC and/or Left Orbital Frontal Lobe), and personalize brain map **20** to reflect these scores.

[0079] Additionally, or alternatively, neurological impairment may include a high-level neurological impairment, such as a reading disability. Evaluation activity **410**EV may produce an evaluation activity **410**EV that is adapted to evaluate functionality of reading-related regions in the brain. Following performance of the evaluation activity **410**EV on UI **50**, evaluation activity **410**EV may collaborate with assessment module **30** to produce an assessment **30**AS or a score of functionalities of one or more brain regions of the subject, based on evaluation activity **410**EV.

[0080] According to some embodiments, evaluation module **40** may collaborate with assessment module **30** to produce assessment **30**AS as a personalized, baseline version of brain map **20**.

[0081] For example, as shown in FIG. **4**B, region stimulus map **20**RSM may associate specific brain functions and/or brain regions of a subject with respective, audiovisual stimuli. Evaluation module **40** may produce assessment **30**AS as a personalized (i.e., pertaining to the specific subject), baseline version of region stimulus map **20**RSM, e.g., representing an initial setting of one or more game parameters (e.g., initial appearance, location, or speed of objects in the game) that may evolve over time (e.g., as part of a treatment trajectory).

[0082] In another example, as shown in FIG. **4**A, evaluation module **40** may produce assessment **30**AS as an initial, personalized, baseline version of a functional region map data structure **20**FRM, that may evolve over time.

[0083] The term "initial" may be used in this context to indicate that assessment module **30** may repeat the assessment process in a plurality of iterations, to produce further assessments **30**AS e.g., in response to further activity of the subject (e.g., games **410**GA/**80**G played by the subject), as further elaborated herein. The term "personal" may be used in this context to indicate that assessment **30**AS may pertain to a specific, relevant subject or patient of diagnosis **20**ED, and may be compared to a "normal" or "cohort" assessments **30**AS that may represent a population of subjects. The term "baseline" may be used in this context to indicate that assessments **30**AS may present a starting point to follow evolution (e.g., improvement or degradation) of the subject's condition, following treatment.

[0084] As shown in FIG. **2**, system **100** may include a selection module **70**, adapted to select one or more brain regions **70**SR based on assessment **30**AS.

[0085] For example, selection module **70** may receive a cohort functional region map **20**FRM, representing mean values of a population of gender and age-similar subjects. Selection module **70** may compare a functional region map **20**FRM of a personalized brain map **20** (denoted **20**P, pertaining to a specific subject) with a functional region map **20**FRM of a cohort brain map **20** (denoted **20**C, and pertaining to a cohort of subjects). Selection module **70** may select **70**SR at least one brain region of the subject that may be characterized by an insufficient score **30**AS, among brain regions participating in a predetermined function of interest (e.g., reading).

[0086] Additionally, or alternatively, selection module **70** may receive a region stimulus map **20**RSM of a cohort brain map **20** (denoted **20**C, representing mean values of a population of gender and age-similar subjects). Selection module **70** may compare a region stimulus map **20**RSM of a personalized brain map **20** (pertaining to a specific subject) with the cohort region stimulus map **20**RSM, to identify and select at least one brain region **70**SR of the subject that may be characterized by insufficient amplitude and/or extent (e.g., in time and space) for stimulating the low-scoring **30**AS brain region of that subject.

[0087] As shown in FIG. **2**, system **100** may include a game generation module **80**, adapted to create at least one audiovisual (e.g., containing audio and/or visual content) curative game **80**G. Curative game **80**G may be designed to stimulate the selected brain region **70**SR based on the subject's brain map data structure **20**, e.g., based on scores **30**AS in functional map **20**FRM and/or based on the association of brain regions to audiovisual stimuli in region stimulus map **20**RSM.

[0088] Additionally, or alternatively, game generation module **80** may be configured to produce a pool of curative games **80**G. Games **80**G of the pool may correspond to the neurological impairment of expert diagnosis **20**ED (e.g., to treat a reading impairment).

[0089] The pool of curative games **80**G may differ by at least one audiovisual game parameter **80**P (e.g., having different colors, sounds, speed, etc.). Game generation module **80** may subsequently collaborate with selection module **70** to select a specific curative game **80**G, designed to stimulate the selected brain region **70**SR based on the subject's brain map **20**.

[0090] Additionally, or alternatively, game generation module **80** may select from a pool of game templates **80**GT, a game template that corresponds to the neurological impairment of expert diagnosis **20**ED (e.g., directed to treating a reading impairment). Game generation module **80** may subsequently adapt at least one game parameter **80**P of the selected game template **80**GT, so as to stimulate the selected brain region **70**SR, according to the subject's brain map **20**.

[0091] For example, game parameter **80**P may include characteristics of movement of one or more objects in curative game **80**G, e.g., saccadic movement, linear movement, rotational movement, etc. Game generation module **80** may adapt game parameter **80**P, to change (e.g., change a movement direction and type), to activate or stimulate a relevant brain region, according to brain map **20** (**20**RSM). For example, a game **80**G that includes game parameters **80**P such as smooth pursuit from left to right may be associated with parietal and temporal lobes on the right hemisphere, while a game **410**GA/**80**G that includes game parameters **80**P such as quick jumps from left to right may be associated with stimulation of the frontal lobes on the left hemisphere.

[0092] According to some embodiments, system **100** may use UI **50** to prompt the subject to play one or more iterations of at least one created game **80**G, and monitor the playing by at least one game monitoring module **90**. Monitoring module **90** may thereby extract a value of at least one game performance parameter **90**GP in the one or more game iterations.

[0093] Game performance parameters **90**GP may include, for example, a measurement of reaction time of the subject, a number of actions (e.g., mouse clicks) the subject has performed (e.g., in comparison to a number of required actions), a total number of completed games (e.g., as portion of a number of games defined by a provider), a number of daily sessions compared to a predefined number, and the like.

[0094] Additionally, or alternatively, game **410**GA/**80**G may be designed to determine a user's ability to follow a moving target, e.g., using a touch screen or mouse curser. Game performance parameters **90**GP may include a measurement of accuracy (e.g., how close to the target did the user click, or a difference between a position of a presented object and a point of a subject's contact), or the subject's capability to visually follow the target (e.g., using an eye movement tracking device). Additionally, or alternatively, game **410**GA/**80**G may include distracting objects, and performance parameters **90**GP may include comparison of success and/or accuracy in relation to the level of distraction (e.g., number and/or movement of distracting objects).

[0095] Additionally, or alternatively, game **410**GA/**80**G may prompt the subject to respond to a task or question. Game performance parameters **90**GP may include a success rate (e.g., correct vs incorrect responses, number of correct as percentage of a total number of responses, etc.), a time required by the subject to answer, a number of consecutive correct answers, and the like.

[0096] Assessment module **30** may subsequently analyze game performance parameter values **90**GP to recalculate assessment **30**AS, and/or update brain map **20** (e.g., **20**RSM and/or map **20**FRM). In other words, assessment module **30** may analyze game performance parameter values **90**GP to determine or identify suboptimal functionality of the one or more selected brain regions **70**SR.

[0097] For example, game monitoring module may produce a standardized performance profile **90**PP, representing a metric (e.g., a mean) of performance parameters **90**GP pertaining to a cohort of gender and age-similar subjects. Assessment module **30** may then analyze performance parameters **90**GP of a specific subject in playing curative game **80**G, in view of standardized performance profile **90**PP, to identify suboptimal functionality of the one or more selected brain regions **70**SR.

[0098] In another example, assessment module **30** may calculate a rate of change **30**RC, across the one or more game **80**G iterations, of a function of a specific selected brain region(s) **70**SR, of a specific subject, as represented by one or more consecutively generated functional region maps **20**FRM. Assessment module **30** may analyze the determined rate of change **30**RC in view of a predetermined baseline rate of change **30**RC (e.g., an expected rate of change **30**RC).

[0099] Assessment module **30** may thereby determine suboptimal functionality of a specific brain region **70**SR according to this analysis. For example, when a rate of change **30**RC in functionality of a brain region of the subject (as reflected by functional region maps **20**FRM) when playing curative game **80**G falls short of an expected, baseline rate of change **30**RC, then assessment module **30** may determine that the relevant brain region is characterized by suboptimal functionality.

[0100] Assessment module **30** may then collaborate with game generation module **80** to adjust at least one game parameter **80**P of the curative game **80**G, so as to stimulate the selected brain region **70**SR, according to the brain map **20**. System **100** may thereby dynamically, and interactively improve the functionality of the relevant brain region **70**SR.

[0101] Additionally, or alternatively, game generation module **80** may collaborate with selection module **70**, to select from a pool of game templates **80**GT, a specific game template **80**GT that corresponds to the neurological impairment of diagnosis **20**ED based on the analysis of the brain functionality rate of change **30**RC. Game generation module **80** may then adapt at least one game parameter **80**P of the selected game template **80**GT, so as to stimulate the selected brain region **70**SR, in accordance with the functional region maps **20**FRM of brain map **20**.

[0102] According to some embodiments, the generation of curative games and analysis of the subject's performance may be an iterative, or repetitive process over time. Each iteration of the iterative process may include the steps of: (a) prompting the subject to play one or more iterations of at least one curative game **80**G on UI **50**; (b) monitoring the subject's playing, to extract a value of at least one game performance parameter **90**GP in the one or more iterations; (c) analyzing the game performance parameter values, to identify suboptimal functionality of one or more selected brain regions **70**SR; and (d) optionally updating brain map data structure **20**, to reflect (or include) a current value, or assessment **30**AS of the identified suboptimal functionality of the one or more selected brain regions **70**SR.

[0103] According to some embodiments, at least one classification module **320** may be, or may include a machine-learning (ML) based model **35**. In such embodiments, ML based model **35** may be dedicated to, or associated with one or more specific brain regions, and may be trained to predict, or assess functionality score **30**AS of the associated brain region(s), based at least in part on game performance parameters **90**GP, as elaborated herein.

[0104] Additionally, or alternatively, brain region assessment module **30** may include one or more machine-learning (ML)-based models **35** that may be trained to calculate, or predict a diagnosis **35**D of one or more brain region(s). Diagnosis **35**D may include, for example functionality score **30**AS, representing functionality of the one or more brain regions.

[0105] Additionally, or alternatively, ML based model(s) **35** may be trained to predict a refined diagnosis **35**D of the neurological impairment of the subject. For example, refined diagnosis **35**D may include a subclass or an evaluation of a severity of the neurological impairment, defined by expert diagnosis **20**ED.

[0106] Additionally, or alternatively, refined diagnosis **35**D may include a refined version of a functional region map **20**FRM and/or a refined version of a region stimulus map **20**RSM of the subject.

[0107] Additionally, or alternatively, refined diagnosis **35**D may include a prognosis of a neurological impairment of diagnosis **20**ED, and/or an expected change in the neurological impairment condition of the subject.

[0108] Additionally, or alternatively, refined diagnosis **35**D may include a recommended treatment, such as a game template **80**GT to be used for creating new curative game **80**G, that may be subsequently prompted to the subject.

[0109] As shown in FIG. **2**, system **100** may obtain, e.g., from at least one Health Care Provider (HCP) computing device **20**H, at least one profile data element **20**PR. Profile data element **20**PR may include, or represent profile information of a subject, including for example the subject's age, gender, ethnicity, and the like.

[0110] Additionally, or alternatively, system **100** may obtain (e.g., from computing device **20**H) at least one medical data element **20**MH, representing a medical history of the subject, such as previous diagnoses of the subject, hospitalizations events, and medication prescribed to the subject.

[0111] According to some embodiments, system **100** may include a feature extraction module **60**, configured to receive an initial set of features, that may include, for example game performance parameters **90**GP (from game monitoring module **90**), medical data elements **20**MH, profile data elements **20**PR, and brain functionality rate of change **30**RC.

[0112] System **100** may (e.g., during a training stage) provide ML model **35** with a plurality of feature vectors **60**F, pertaining to a plurality of use-cases or subjects as input. System **100** may train ML model **35** by an appropriate training scheme (e.g., by a backward-propagation process), to predict refined diagnosis **35**D as a function of the feature vectors **60**F.

[0113] ML model **35** may subsequently (e.g., during an inference stage), receive a target feature vector **60**F, pertaining to a specific use-case or subject of interest. ML model **35** may then predict refined diagnosis **35**D as a function of target feature vector **60**F, in accordance with its training.

[0114] Additionally, or alternatively, system **100** may obtain a trained ML based model **35**, and infer ML model on (i) the one or more game performance parameters, and (ii) the expert diagnosis, to predict a refined diagnosis **35**D of the neurological impairment of the subject.

[0115] Additionally, or alternatively, system **100** may infer ML based model **35** on the one or more game performance parameters **90**GP, to produce a diagnosis **35**D that may include prediction of suboptimal functionality of at least one brain region of the subject. System **100** may subsequently update the brain map data structure **20** of that subject to reflect the predicted suboptimal functionality of the at least one brain region.

[0116] Additionally, or alternatively, feature extraction module **60** may collaborate with ML model **35** to extract, from an initial set of features, a reduced set of features **60**F that are most prominent for predicting refined diagnosis **35**D. In a subsequent inference stage, system **100** may infer ML model **35** on the reduced set of features **60**F, to predict refined diagnosis **35**D.

[0117] For example, feature extraction module **60** may determine that a rate of change **30**RC of function of a specific region of the one or more selected brain regions **70**SR, across gaming iterations is a prominent feature for predicting refined diagnosis **35**D. System **100** may subsequently infer ML based model **35** on (i) the determined rate of change **30**RC, and (ii) the expert diagnosis **20**ED, to predict a refined diagnosis **35**D of the neurological impairment of the subject.

[0118] In another example, feature extraction module **60** may determine that at least one profile data element **20**PR and/or at least one medical data element **20**MH may be prominent for predicting refined diagnosis **35**D. System **100** may subsequently infer ML based model **35** further on profile data element **20**PR and/or medical data element **20**MH to produce refined diagnosis **35**D.

[0119] In yet another example, refined diagnosis **35**D may include a recommendation for a specific game **80**G and/or game template **80**GT, to be used for treating the relevant neural impairment. In such embodiments, game generation module **80** may adapt at least one game parameter **80**P of a selected game template **80**GT based on at least one profile data element **20**PR and/or medical data element **20**MH, to stimulate the selected brain region **70**SR, according to the brain map **20**.

[0120] Reference is now made to FIGS. **6**A and **6**B which present data that may be accumulated from a subject, representing a use case of an embodiment of the invention. The information depicted in FIGS. **6**A and **6**B may be presented via output device **8** (e.g., UI **50**), and may serve a care giver or physician to obtain an overview of a patient's condition.

[0121] In the example of FIGS. **6**A and **6**B, it is clear that the main regions of interest are the parietal lobes on both sides, the left cerebellum, the frontal lobe on the right (mainly the dorsolateral prefrontal cortex (DLPFC)) as well as the indirect pathway of the basal ganglia on the right. It may also be beneficial to activate the midbrain and the pons of the brainstem, and the right temporal lobes, although the latter appears to be of secondary importance.

[0122] Based on these selected regions **70**SR, system **100** may prompt the patient to play the following games **80**G, having the associated parameters **80**P:

[0123] A first game **80**G may aim to find and identify whether a presented object (e.g., a body part) belongs to the right or left side. Parameters **80**P of the game may dictate that the background for the game will be texturized, with cold (e.g., bluish) hues. At high levels of the game, objects will be presented as rotating in a clockwise direction.

[0124] Rationale for selecting these parameters **80**P includes: (a) The skill of determining right from left is linked to the left parietal lobe; (b) cold background hues affect the right brain hemisphere more than the left one; (c) The task of tracing an object over texturized background activates the parietal lobe more than the temporal lobe; and (d) Clockwise rotation simulates a movement of the head in the opposite direction, thus activating the vestibular system and the cerebellum on the left hemisphere.

[0125] A second game **80**G may have a goal of matching facial expressions (e.g., an image of a smiling child) to a word expressing emotion (e.g., "happy"). Parameters **80**P of the game may dictate that the background for the game will be texturized and have cold hues. At high levels of the game, objects will be presented as rotating in a clockwise direction. Movement of objects across the screen will be smooth (without jitters), and will include horizontal (left to right), diagonal (top left to bottom right), and vertical (top to bottom) motions. The emotion words will be presented at the bottom left of the UI **50** screen.

[0126] Rationale for selecting these parameters **80**P includes: (a) Recognition of facial expressions, as part of non-verbal communication, is associated with the right hemisphere (b) Horizontal movement from left to right is associated with right parietal/temporal lobes. It is also closely related to the pons of the brain stem. (c) Vertical movement from top to bottom is related to the right hemisphere, as well as the middle brain (mesencephalon) of the brain stem. (d) Diagonal movement from top-left to bottom-right is related to the right hemisphere, as well as to the left cerebellum. (e) Placement of objects on the screen will be mainly on the left side of the screen.

[0127] A third game **80**G may present a goal of finding objects that had previously appeared in a sequence of images shown on the screen. This game will examine a patient's working memory, control of saccadic eye movements, and ability to focus vision. Parameters **80**P of the game may dictate that direction of movement of the objects on the screen will be right to left and/or bottom-right to top-left.

[0128] Rationale for selecting these parameters **80**P is as follows: (a) Saccadic eye movements are related to the frontal lobes of the same side as that which the movement originates. (b) Stopping the saccadic jitters is mainly related to the cerebellum, on the same side as that of the direction of movement. Pertaining to this example, the stimulated lobes would be the right frontal lobe and the left cerebellum.

[0129] A fourth game **80**G may require visual inversion capabilities. In this game, a user will need to determine what objects would look like subsequent to their rotation. This game will activate the user's skill of spatial awareness. Parameters **80**P of the game may dictate a background as described above, and show complex objects such as animals.

[0130] Rationale for selecting these parameters **80**P is as follows: (a) Visual inversion is mainly associated with the parietal lobes, especially on the right hemisphere. (b) Spatial awareness is related to normal functioning of the cerebellum.

[0131] A fifth game **80**G may require the user to identify characters on the screen, match them to characters on a side of the screen, and either click, or not click on the characters according to the match result. This game will evoke two main components: optokinetic capability, and a Go/No-go activity. Optokinetic activity is related to the parietal lobes, where horizontal representation is related to the pons, and vertical representation is related to the midbrain. Go/No-Go activity requires efficient activity of the indirect pathway of the basal ganglia. Parameters of backgrounds and object representation will be as described above. At high levels of the game, a component of visual inversion as described above may be added.

[0132] A test case illustrating the operation of system **100** may include a clinical assessment and treatment process as follows:

[0133] Evaluation module **40** may receive input data for a subject, which may include an expert diagnosis **20**ED, such as Autism Spectrum Disorder (ASD), which may be associated with right hemisphere deficit, and a profile data elements **20**PR, such as age and gender. Evaluation module **40** may further obtain (e.g., via UI **50**) results from an initial questionnaire **410**QU, which may indicate reduced functionality in various brain regions, including the right dorsolateral prefrontal cortex (DLPFC), right orbital frontal cortex, right parietal and inferior parietal regions, right basal ganglia indirect pathway, and left cerebellum.

[0134] Based on the input data, activity selection module **400** may select, or update a list of assessment games **410**GA. Brain assessment module **30** may determine a suspicion of right hemisphere deficit with cerebellar involvement, and reflect that deficit in the functional region map **20**FRM of a personalized (e.g., pertaining to the specific subject) brain map **20**.

[0135] Evaluation module **40** may then initiate an assessment phase by prompting the subject to engage in assessment games **410**GA via UI **50**. The assessment games may include:

[0136] A first game **410**GA-**1** of hitting targets on the screen. This game may focus on distinguishing right from left hemisphere function and cerebellar involvement, as represented in the region stimulus map **20**RSM of brain map **20**. Game monitoring module **90** may consider correlations between brain regions and corresponding stimuli in region stimulus map **20**RSM, to monitor and analyze game performance parameters **90**GP such as: (a) success rate with various changes to game parameters **80**P; (b) Target placement on the screen, where targets on the left may challenge the right hemisphere more, as indicated by region stimulus map **20**RSM; (c) timing and accuracy of contact to assess cerebellar function (d) reaction time to assess frontal lobe function; and (e) movement direction to assess parietal/temporal lobe involvement.

[0137] A second game **410**GA-**2** of pursuing a target on the screen. This game may focus on challenging parietal vs temporal lobe function. Game monitoring module **90** may consider correlations between brain regions and corresponding stimuli in region stimulus map **20**RSM, to monitor, and analyze game performance parameters **90**GP such as: (a) Smoothness of pursuit over textured vs solid backgrounds; and (b) Vertical vs horizontal movement challenges (thereby assessing pons vs mesencephalon functionality).

[0138] Activity selection module **400** may continue the assessment phase with increasing game complexity and parameter changes **80**P. Additional game parameters **80**P and performance parameters **90**GP that may be evaluated include (a) Go/No-go tasks; (b) Smooth vs non-smooth movement, requiring smooth pursuit or saccadic eye movements; (c) Obstacle and target placement in various visual field quadrants; (d) Positioning of distractors, having various auditory and/or visual properties, and the like.

[0139] Additionally or alternatively, game monitoring module **90** may collect and analyze various game performance parameters **90**GP during the assessment phase, including for example (a) Success rates with various parameters; (b) Timing of responses (e.g., early or late clicks); (c) Accuracy of responses (e.g., clicking at the correct location); (d) Indicators of hyperactivity/impulsivity (e.g., excessive mouse clicks); (e) Indicators of hypoactivity (e.g., missed mouse clicks); and (f) Reaction times.

[0140] Upon completion of the assessment phase, brain assessment module **30** may generate a profile of the subject's brain function, identifying areas of reduced functionality as represented in the functional region map **20**FRM of brain map **20**. Based on this profile of brain map **20**, game generation module **80** may create personalized curative games **80**G designed to challenge, or stimulate the identified areas of reduced functionality, utilizing the associations between brain regions and audiovisual stimuli specified in the region stimulus map **20**RSM. Game generation module **80** may calibrate the difficulty level of these curative games **80**G to match the subject's performance level in the assessment games **410**GA. Additionally, or alternatively, the difficulty level of these curative games **80**G may dynamically evolve over time, as a function of a rate of change **30**RC (e.g., improvement) in one or more parameters of game performance **90**GP. For example, a speed of the pursued target may increase between games, when a game performance parameter **90**GP such as a number of unnecessary mouse clicks is improved (e.g., in this case-reduced).

[0141] System **100** may thereby provide an appropriate, dynamically changing level of challenge for the subject's current capabilities, as reflected in the subject's personalized brain map **20**.

[0142] Reference is now made to FIG. **7**, which is a flow diagram, depicting a method of creating curative games by at least one processor, according to some embodiments of the invention.

[0143] As shown in step S**1005**, the at least one processor (e.g., processor **2** of FIG. **1**) may obtain a brain map data structure (e.g., **20** of FIGS. **2**, **4**A, **4**B), associating specific brain regions with respective, audiovisual stimuli.

[0144] As shown in steps S**1010** and S**1015**, the at least one processor **2** may receive an expert diagnosis (e.g., **20**ED of FIG. **2**) of a neurological impairment of a subject. Based on the expert diagnosis, the at least one processor may prompt the subject to engage in at least one evaluation activity (e.g., **410**EV of FIG. **2**) that corresponds to the neurological impairment, e.g., via a UI (e.g., UI **50** of FIG. **2**).

[0145] As shown in steps S**1020** and S**1025**, the at least one processor **2** may calculate or assess a functionality of one or more brain regions of the subject based on the evaluation activity **410**EV, and select (e.g., **70**SR of FIG. **2**) one or more brain regions based on the assessed functionality.

[0146] As shown in step S**1030**, the at least one processor **2** may subsequently create at least one audiovisual, curative game (e.g., **80**G of FIG. **2**) designed to stimulate the selected brain region **70**SR, based on the brain map data structure **20**.

[0147] Embodiments of the invention may include a practical application in the technological field of assistive diagnostics and treatment of neurological impairments. As elaborated herein, embodiments of the invention may automatically identify regions in a user's (e.g., a "subject" or "patient") brain that perform poorly (e.g., is attributed a low score **35**D/**30**AS), and devise personalized, curative stimuli (e.g., games **80**G) for activating those specific regions. Embodiments of the invention may iteratively adjust the stimuli **80**G, in a repetitive and dynamic manner, to accustom the evolution or change in the user's performance of the presented games **80**G.

[0148] Unless explicitly stated, the method embodiments described herein are not constrained to a particular order or sequence. Furthermore, all formulas described herein are intended as examples only and other or different formulas may be used. Additionally, some of the described method embodiments or elements thereof may occur or be performed at the same point in time.

[0149] While certain features of the invention have been illustrated and described herein, many modifications, substitutions, changes, and equivalents may occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

[0150] Various embodiments have been presented. Each of these embodiments may of course include features from other embodiments presented, and embodiments not specifically described may include various features described herein.

1. A method of producing a curative game by at least one processor, the method comprising:

obtaining a brain map data structure, associating specific brain regions with respective, audiovisual stimuli;

receiving an expert diagnosis of a neurological impairment of a subject;

based on the expert diagnosis, prompting the subject to engage in at least one evaluation activity that corresponds to the neurological impairment, via a user interface (UI);

assessing a functionality of one or more brain regions of the subject based on the evaluation activity and brain map data structure;

selecting one or more brain regions based on the assessed functionality; and

creating at least one audiovisual, curative game designed to stimulate the selected brain region based on the brain map data structure.

2. The method of claim **1**, wherein assessing said functionality is performed iteratively, wherein each iteration comprises:

prompting the subject to engage in an evaluation activity;

assessing a functionality of one or more brain regions of the subject based on outcome of the evaluation activity;

updating the brain map data structure, based on the assessed functionality, thereby producing a personalized brain map data structure; and

employing a decision tree, to select an evaluation activity for a subsequent iteration, based on the personalized brain map data structure.

3. The method of claim **2**, wherein the evaluation activity comprises a questionnaire, and wherein the method further comprises:

presenting the questionnaire to the subject via the UI;

obtaining the subject's response to the questionnaire via the UI;

assessing the functionality of the one or more brain regions of the subject based on the subject's response and brain map; and

personalizing the brain map to reflect the assessed functionality of one or more brain regions of the subject.

4. The method of claim **2**, wherein the evaluation activity comprises an evaluation game, and wherein the method further comprises:

presenting the evaluation game to the subject via the UI;

monitoring the subject's playing, to extract a value of at least one evaluation game performance parameter;

assessing the functionality of the one or more brain regions of the subject based on the at least one evaluation game performance parameter; and

personalizing the brain map to reflect the assessed functionality of one or more brain regions of the subject.

5. The method of claim **1**, wherein creating a curative game comprises:

selecting, from a pool of game templates, a game template that corresponds to the neurological impairment; and

adapting at least one game parameter of the selected game template, so as to stimulate the selected brain region, based on the personalized brain map data structure.

6. The method of claim **5**, further comprising an iterative process, wherein each iteration comprises:

prompting the subject to play, via the UI, one or more iterations of at least one curative game;

monitoring the subject's playing, to extract a value of at least one game performance parameter in the one or more iterations;

analyzing the game performance parameter value, to identify suboptimal functionality of the one or more selected brain regions; and updating the brain map data structure to reflect the identified suboptimal functionality of the one or more selected brain regions.

7. The method of claim **6**, wherein identifying suboptimal functionality comprises:

determining a rate of change across the one or more iterations, of function of a specific region of the one or more selected brain regions; and

analyzing the determined rate of change in view of a predetermined baseline rate of expected change, to identify the suboptimal functionality.

8. The method of claim **6**, further comprising adjusting at least one game parameter of the created game based on the brain map data structure, so as to stimulate the selected brain region of the identified suboptimal functionality.

9. The method of claim **5**, further comprising:

selecting, from a pool of game templates, a specific game template that corresponds to the neurological impairment; and

adapting at least one game parameter of the selected game template based on the brain map data structure, so as to stimulate the selected brain region of the identified suboptimal functionality.

10. The method of claim **6**, further comprising:

obtaining a pretrained machine learning (ML) based model; and

inferring the ML based model on (i) the one or more game performance parameters, and (ii) the expert diagnosis, to predict a refined diagnosis of the neurological impairment of the subject.

11. The method of claim **6**, further comprising:

determining a rate of change across the one or more iterations, of functionality of a specific region of the one or more selected brain regions; and

inferring an ML-based model on (i) the determined rate of change, and (ii) the expert diagnosis, to predict a refined diagnosis of the neurological impairment of the subject.

12. The method of claim **6**, further comprising:

obtaining a pretrained ML-based model;

inferring the ML based model on the one or more game performance parameters, to predict suboptimal functionality of at least one brain region of the subject; and

updating the brain map data structure to reflect the predicted suboptimal functionality of the at least one brain region.

13. The method of claim **5**, wherein creating a curative game further comprises:

obtaining at least one profile data element, representing a profile of the subject;

obtaining at least one medical data element, representing a medical history of the subject; and

adapting a game parameter of the selected game template based on the at least one profile data element and the at least one medical data element, so as to stimulate the selected brain region, according to the brain map data structure.

14. A system for treating a neurological impairment of a subject, the system comprising a non-transitory memory device, wherein modules of instruction code are stored, and at least one processor associated with the memory device, and configured to execute the modules of instruction code, whereupon execution of said modules of instruction code, the at least one processor is configured to:

obtaining a brain map data structure, associating specific brain regions with respective, audiovisual stimuli;

receiving an expert diagnosis of a neurological impairment of a subject;

based on the expert diagnosis, prompting the subject to engage in at least one evaluation activity that corresponds to the neurological impairment, via a user interface (UI);

based on the evaluation, producing an assessment of functionality of one or more brain regions of the subject;

selecting one or more brain regions based on said assessment;

creating at least one audiovisual, curative game designed to stimulate the selected brain region based on the brain map data structure; and

prompting the subject to play the created game via the UI.

15. The system of claim **14**, wherein the at least one processor is configured to prompt the subject to engage in an evaluation activity by:

presenting a questionnaire to the subject via the UI;

obtaining the subject's response to the questionnaire via the UI;

assessing the functionality of the one or more brain regions of the subject based on the subject's response; and

personalizing the brain map to reflect the assessed functionality of one or more brain regions of the subject.

16. The system of claim **14**, wherein the at least one processor is configured to prompt the subject to engage in an evaluation activity by:

presenting evaluation game to the subject via the UI;

monitoring the subject's playing, to extract a value of at least one evaluation game performance parameter;

assessing the functionality of the one or more brain regions of the subject based on the at least one evaluation game performance parameter; and

personalizing the brain map to reflect the assessed functionality of one or more brain regions of the subject.

17. The system of claim **14**, wherein the at least one processor is configured to create the at least one curative game by:

selecting, from a pool of game templates, a game template that corresponds to the neurological impairment; and

adapting at least one game parameter of the selected game template, so as to stimulate the selected brain region, based on the brain map data structure.

18. The system of claim **14**, wherein the at least one processor is configured to implement an iterative process, wherein each iteration comprises:

prompting the subject to play, via the UI, one or more iterations of at least one created game;

monitoring the subject's playing, to extract a value of at least one game performance parameter in the one or more iterations;

analyzing the game performance parameter values, to identify suboptimal functionality of the one or more selected brain regions; and

updating the brain map data structure to reflect the identified suboptimal functionality of the one or more selected brain regions.

19. The system of claim **18**, wherein the at least one processor is configured to identify suboptimal functionality by:

determining a rate of change across the one or more iterations, of function of a specific region of the one or more selected brain regions; and

analyzing the determined rate of change in view of a predetermined baseline rate of expected change, to identify the suboptimal functionality.

20. The system of claim **18**, wherein the at least one processor is configured to adjust at least one game parameter of the created game based on the brain map data structure, so as to stimulate the selected brain region of the identified suboptimal functionality.

* * * * *