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(54) **METHOD AND SYSTEM FOR ACQUISITION OF LITERACY**

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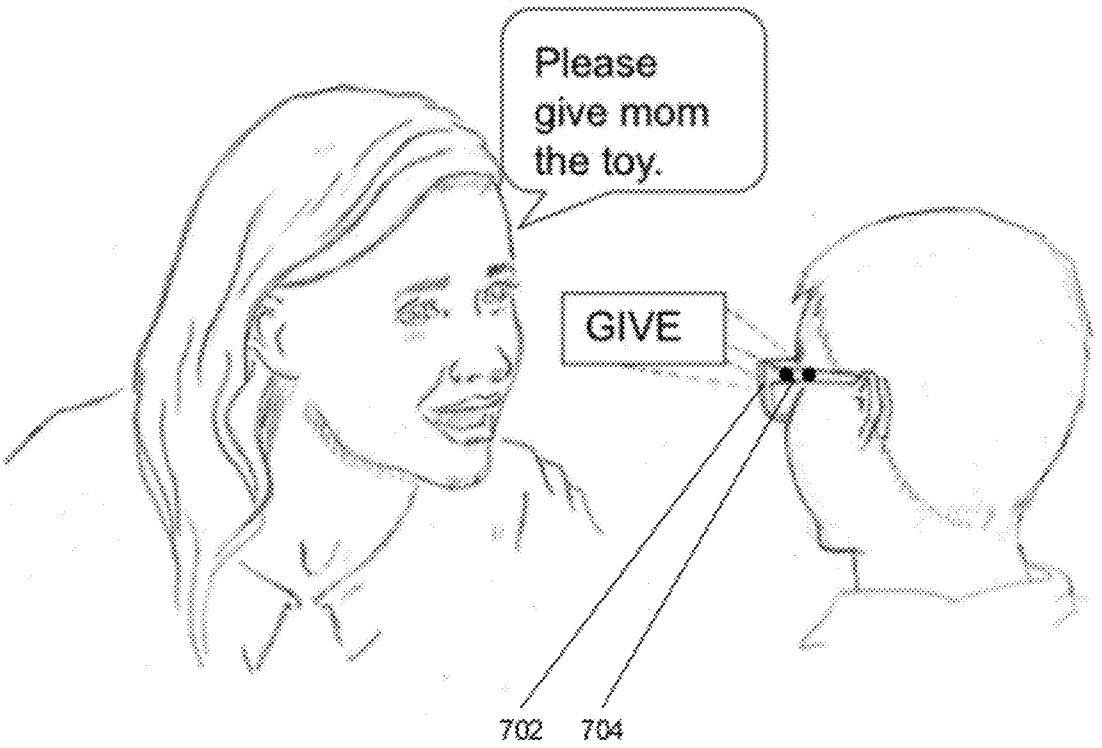
(57) **ABSTRACT**

A computer-implemented method for enabling a child to learn to read, including maintaining a data store with information that characterizes the reading capabilities of children, receiving a stream of sensor data from one or more input devices, the sensor data representing the speech of a person speaking, the person being either an adult or a child, or a sequence of scenes, identifying a meaningful utterance or a meaningful scene from the stream of sensor data, representing the meaningful utterance or meaningful scene in written text using words and grammar appropriate to the reading level of the child, based on information stored in the data store, providing the output text to a display device for presentation to the child, and receiving user feedback.



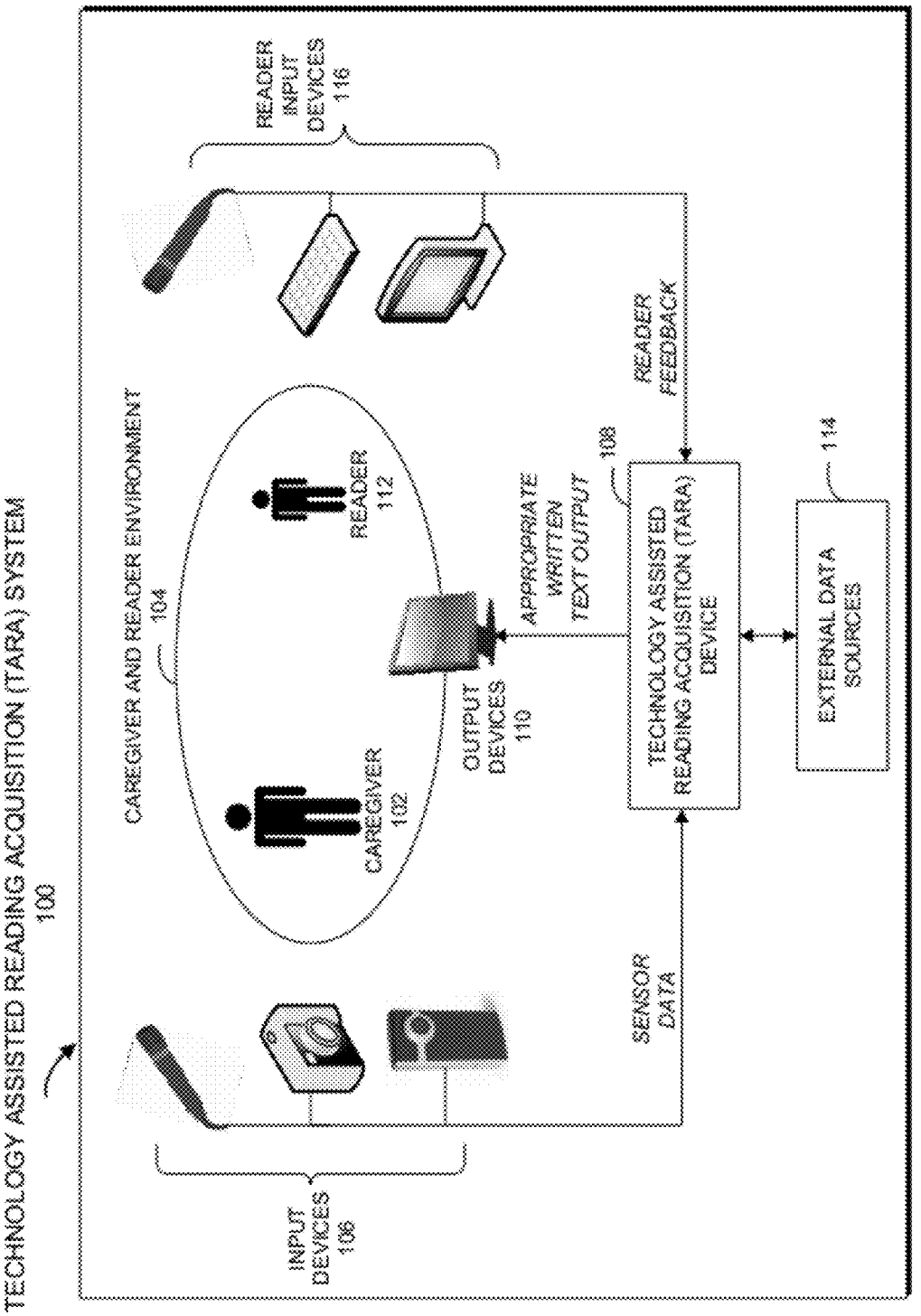

TECHNOLOGY ASSISTED READING ACQUISITION (TARA) SYSTEM
100
READER INPUT DEVICES 116
CAREGIVER AND READER ENVIRONMENT
104
READER 112
CAREGIVER 102
OUTPUT DEVICES 110
APPROPRIATE WRITTEN TEXT OUTPUT
108
READER FEEDBACK
TECHNOLOGY ASSISTED READING ACQUISITION (TARA) DEVICE
114
EXTERNAL DATA SOURCES
SENSOR DATA
INPUT DEVICES 106

FIG. 1

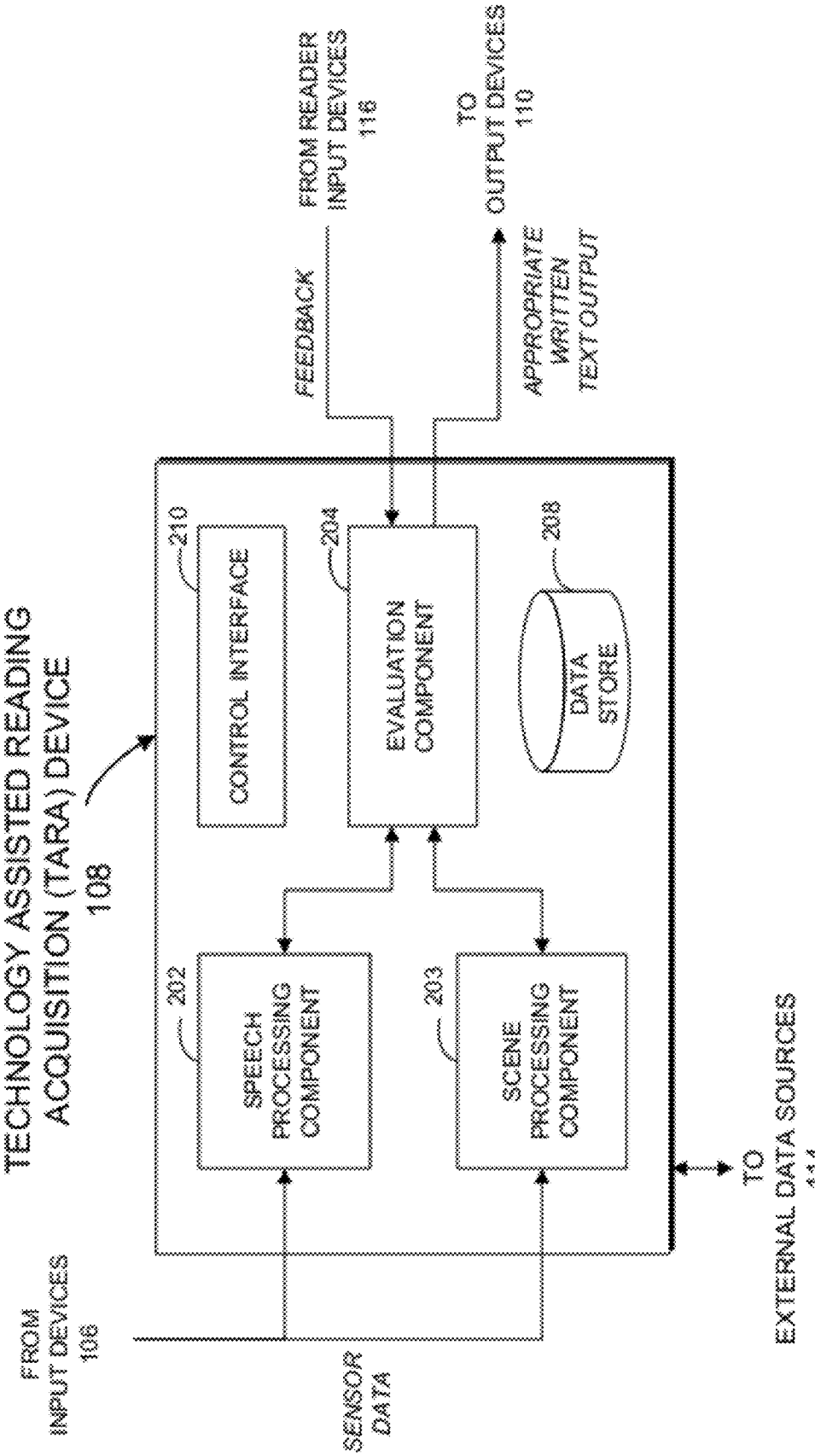

TECHNOLOGY ASSISTED READING ACQUISITION (TARA) DEVICE
108
CONTROL INTERFACE
210
EVALUATION COMPONENT
204
DATA STORE
208
SPEECH PROCESSING COMPONENT
202
SCENE PROCESSING COMPONENT
203
FROM INPUT DEVICES 106
SENSOR DATA
TO EXTERNAL DATA SOURCES 114
FEEDBACK
FROM READER INPUT DEVICES 116
APPROPRIATE WRITTEN TEXT OUTPUT
TO OUTPUT DEVICES 110

FIG. 2

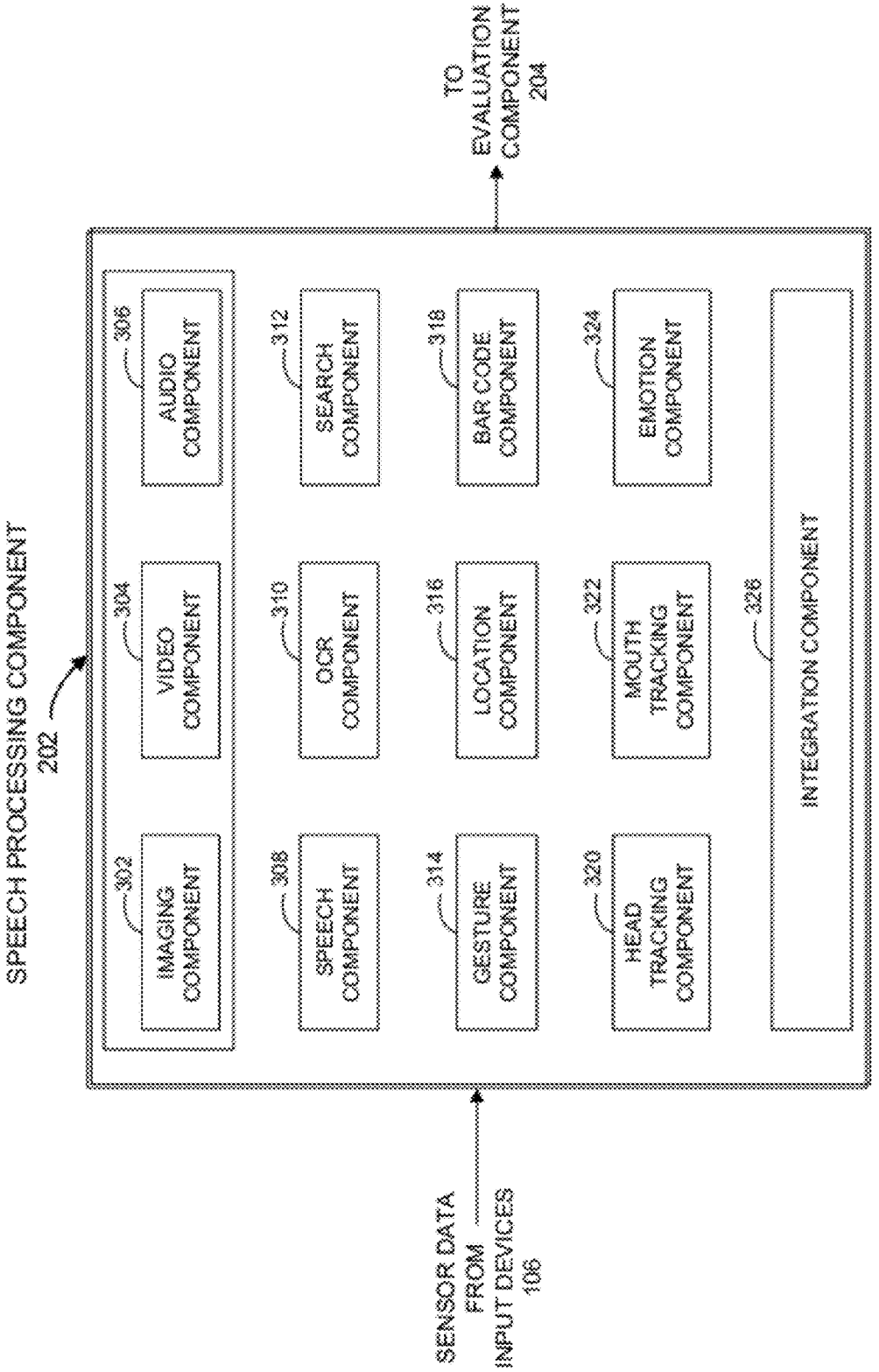

SPEECH PROCESSING COMPONENT
202
TO EVALUATION COMPONENT 204
SENSOR DATA FROM INPUT DEVICES 106
IMAGING COMPONENT
302
VIDEO COMPONENT
304
AUDIO COMPONENT
306
SPEECH COMPONENT
308
OCR COMPONENT
310
SEARCH COMPONENT
312
GESTURE COMPONENT
314
LOCATION COMPONENT
316
BAR CODE COMPONENT
318
HEAD TRACKING COMPONENT
320
MOUTH TRACKING COMPONENT
322
EMOTION COMPONENT
324
INTEGRATION COMPONENT
326

FIG. 3

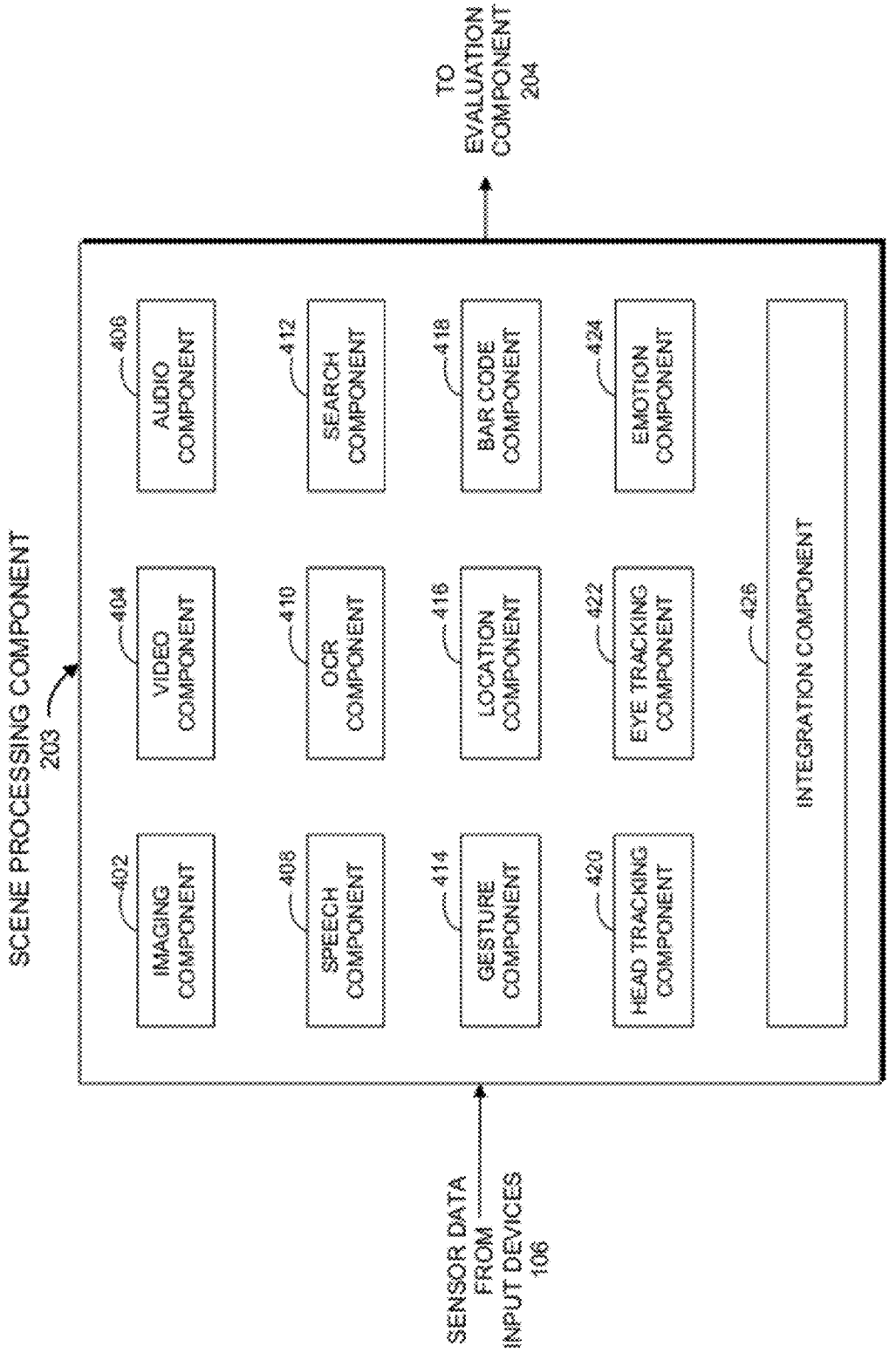

SCENE PROCESSING COMPONENT
203
TO EVALUATION COMPONENT 204
SENSOR DATA FROM INPUT DEVICES 106
402 IMAGING COMPONENT
404 VIDEO COMPONENT
406 AUDIO COMPONENT
408 SPEECH COMPONENT
410 OCR COMPONENT
412 SEARCH COMPONENT
414 GESTURE COMPONENT
416 LOCATION COMPONENT
418 BAR CODE COMPONENT
420 HEAD TRACKING COMPONENT
422 EYE TRACKING COMPONENT
424 EMOTION COMPONENT
426 INTEGRATION COMPONENT

FIG. 4

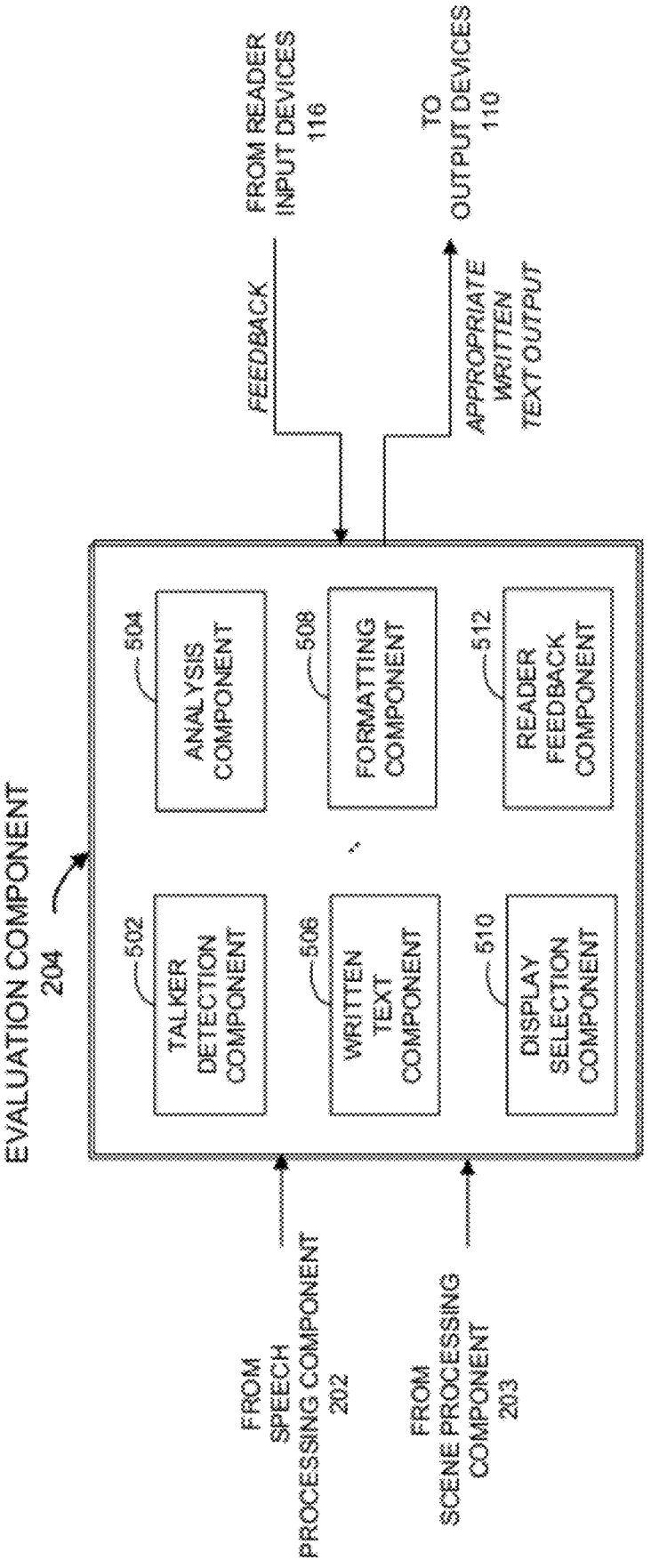

FROM READER INPUT DEVICES 116
TO OUTPUT DEVICES 110
FEEDBACK
APPROPRIATE WRITTEN TEXT OUTPUT
EVALUATION COMPONENT 204
502
TALKER DETECTION COMPONENT
504
ANALYSIS COMPONENT
506
WRITTEN TEXT COMPONENT
508
FORMATTING COMPONENT
510
DISPLAY SELECTION COMPONENT
512
READER FEEDBACK COMPONENT
FROM SPEECH PROCESSING COMPONENT 202
FROM SCENE PROCESSING COMPONENT 203

FIG. 5

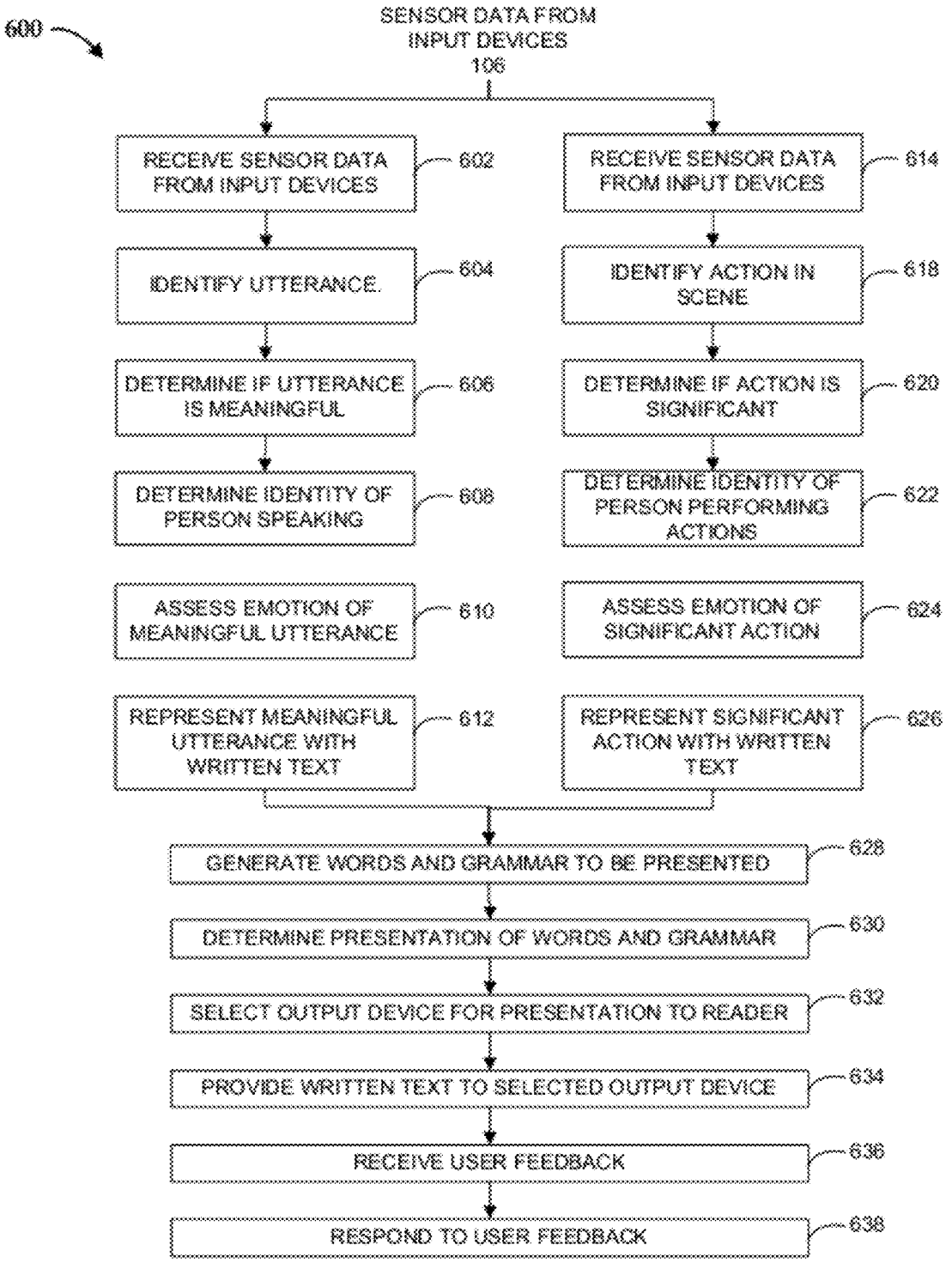

600
SENSOR DATA FROM INPUT DEVICES 106
RECEIVE SENSOR DATA FROM INPUT DEVICES
602
IDENTIFY UTTERANCE.
604
DETERMINE IF UTTERANCE IS MEANINGFUL
606
DETERMINE IDENTITY OF PERSON SPEAKING
608
ASSESS EMOTION OF MEANINGFUL UTTERANCE
610
REPRESENT MEANINGFUL UTTERANCE WITH WRITTEN TEXT
612
RECEIVE SENSOR DATA FROM INPUT DEVICES
614
IDENTIFY ACTION IN SCENE
618
DETERMINE IF ACTION IS SIGNIFICANT
620
DETERMINE IDENTITY OF PERSON PERFORMING ACTIONS
622
ASSESS EMOTION OF SIGNIFICANT ACTION
624
REPRESENT SIGNIFICANT ACTION WITH WRITTEN TEXT
626
GENERATE WORDS AND GRAMMAR TO BE PRESENTED
628
DETERMINE PRESENTATION OF WORDS AND GRAMMAR
630
SELECT OUTPUT DEVICE FOR PRESENTATION TO READER
632
PROVIDE WRITTEN TEXT TO SELECTED OUTPUT DEVICE
634
RECEIVE USER FEEDBACK
636
RESPOND TO USER FEEDBACK
638

FIG. 6

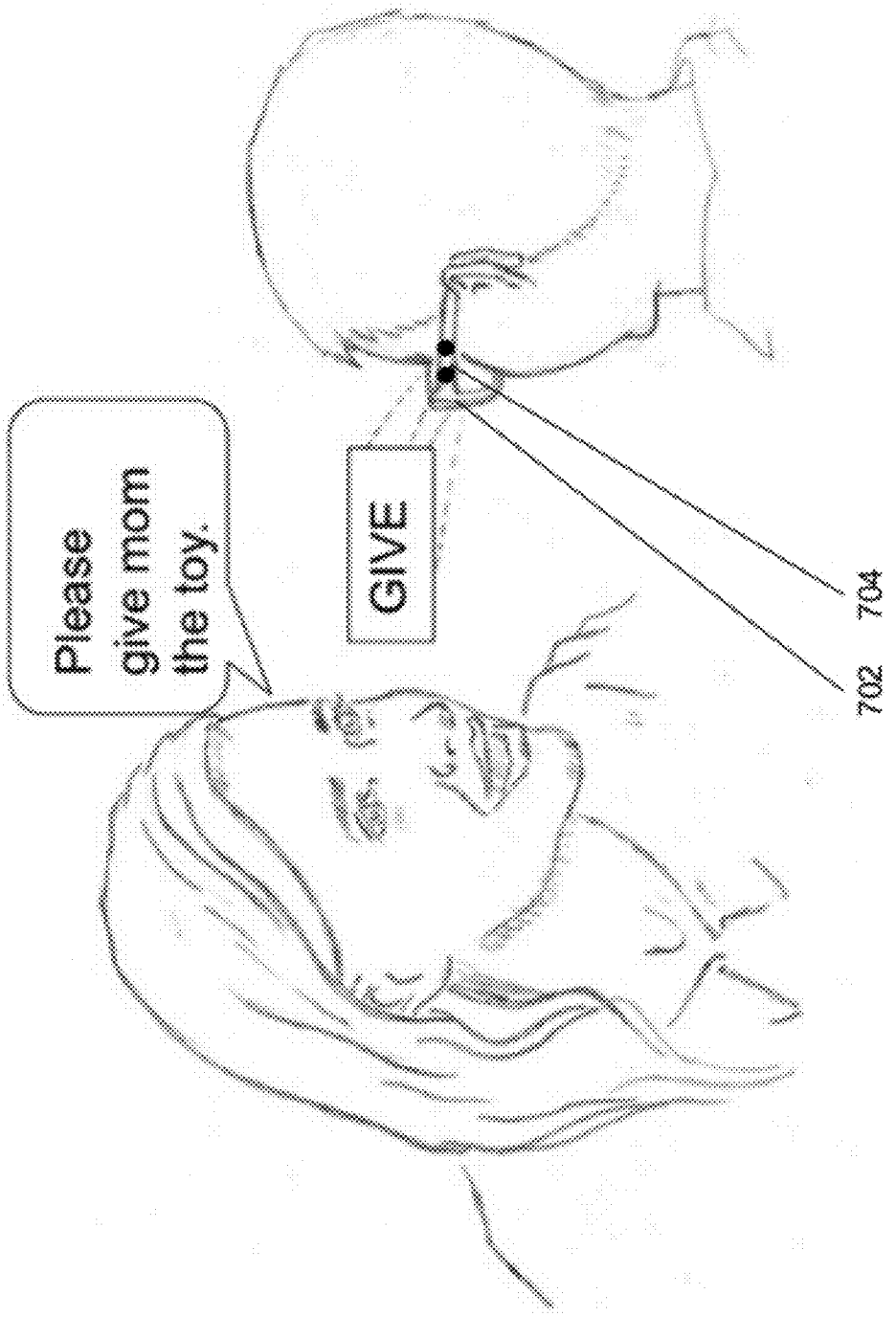


FIG. 7

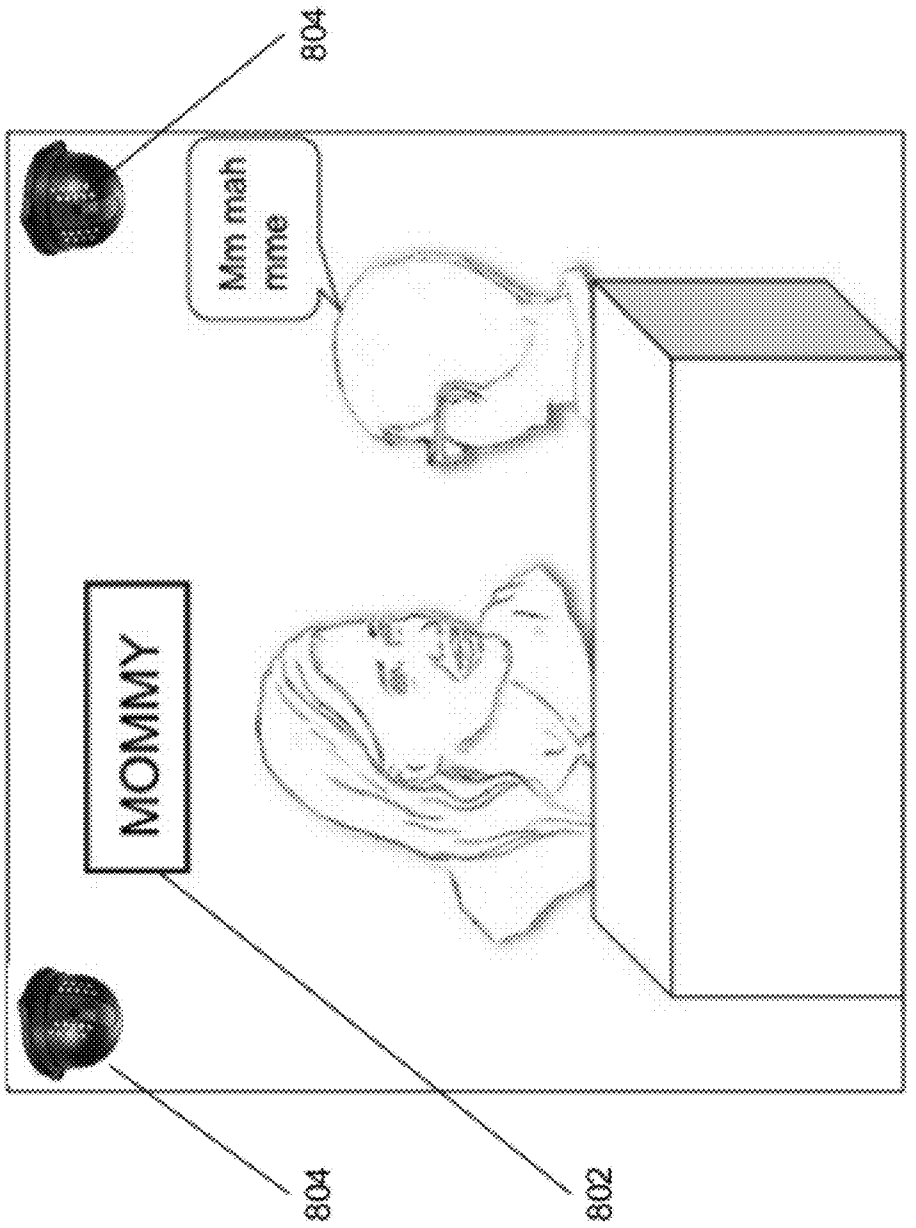


FIG. 8

METHOD AND SYSTEM FOR ACQUISITION OF LITERACY

PRIORITY REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit from U.S. Provisional Patent Application No. 61/390,259, filed on Oct. 6, 2010, by inventor Dominic William Massaro, entitled DIGITAL LEARNING OF WRITTEN LANGUAGE WITHOUT FORMAL INSTRUCTION.

FIELD OF THE INVENTION

[0002] The subject invention relates to written language and its acquisition. More specifically, the invention is directed towards a device and system that enables illiterate infants, toddlers, and young children to learn to read and acquire literacy at an early age before formal schooling begins.

BACKGROUND OF THE INVENTION

[0003] Most researchers and educators contend that spoken language is seamlessly acquired from birth onward by natural interactions with persons whereas the acquisition of written language requires formal instruction and schooling. In contrast, the theory upon which the present invention is based is that written language understanding, or literacy, can be acquired seamlessly if it is constantly available in the same way that spoken language is available.

[0004] Many scientists and researchers believe that children are not ready to read until at least the age of five. Many developmental psychologists and neuroscientists claim that early reading before school age is not biologically or behaviorally possible.

[0005] Most reading specialists believe that reading must be taught via speech and, therefore, should not be taught until spoken language has been mastered to a significant degree. Given this pedagogical framework, written language is not usually presented for reading until the child gains expertise in spoken language and attends school for formal instruction. When written language is introduced, it is in the context of directed instruction that usually involves building phonological awareness, learning the alphabet, learning sight words, and sounding out words.

[0006] Popular commercial products for learning to read generally require instructional pedagogy and practice wherein the learning process is highly contingent on the child's understanding of spoken language. For example, some companies market early reading products that make the learning of written words contingent on pairing them with spoken language.

[0007] Evidence from behavioral and neuroscience has documented so-called critical periods in audition, vision, and language. These critical periods represent periods in a child's lifespan that are crucial for development. In contrast to later in life, the brains of young children are especially plastic, or malleable. Deprivation of sensory or linguistic input during this time leads to a substantial deficit of the sensory system or in the specific language ability of the child. Therefore, minimizing appropriate written input during this period could put the child at a disadvantage in learning to read when schooling begins.

[0008] Thus, it would be advantageous to provide a system in which written language is provided to the developing child soon after birth at an appropriate level and in an appropriate format. Such a system would automatically recognize spoken language as well as the visual elements of the environment in which speech is occurring. It would then present some written description of the speech and/or the scene to the child. Moreover, it would be advantageous for reading acquisition if the written description were appropriate to the child's level of understanding.

SUMMARY OF THE DESCRIPTION

[0009] The present invention exploits current knowledge and developments in behavioral science and technology to provide methods for automatically recognizing the meaning inherent in the illiterate child's experience, and describing that experience in a written language form that is appropriate to the perceptual, cognitive, and linguistic capabilities of the child.

[0010] The present invention is intended to extract the relevant meanings embedded in a child's experience and to describe some of that experience in written language. It uses two methods to recognize and convert the child's experience of spoken language into written language. The first method is to recognize the speech that is being spoken during the experience. The second method is to recognize the scene, the objects, and the actions it contains.

[0011] The present invention analyzes a caregiver's and/or child's speech to determine the meaning of the speech. In one embodiment, the present invention uses acoustic recognition of speech supplemented by methods that track a caregiver's facial movements and gestures to help recognize what is being spoken by the person talking. A modified form of the recognized speech is then presented in writing to children who have not yet mastered reading.

[0012] In one embodiment, the present invention uses methods such as face and gesture recognition to identify the person talking.

[0013] Using scene and object analysis as well as analysis of the actions of a caregiver and the child the subject invention determines scenes from the environment that are currently meaningful to the child. This meaning is presented in writing at a level appropriate to children during their preschool years.

[0014] In certain embodiments, vocabulary and grammar of written text are adjusted to the level of the child. In other embodiments, the format of written text is adjusted to the level of the child.

[0015] In one embodiment, a computer-implemented method is provided for enabling a child to learn to read, including maintaining a data store with information that characterizes the reading capabilities of children, receiving a stream of sensor data from one or more input devices, the sensor data representing the speech of a person speaking, the person being either an adult first person, or a child second person, identifying a meaningful utterance from the stream of sensor data, representing the utterance in written text using words and grammar appropriate to the reading level of the child, based on information stored in the data store, and providing the output text to a display device for presentation to the child.

[0016] In yet another embodiment, the subject invention provides a computer-implemented method for enabling a child to learn to read, including maintaining a data store with information that characterizes the reading capabilities of children, receiving a stream of sensor data from one or more input devices, said sensor data representing a sequence of scenes, each scene including an adult first person and a child second

person, identifying a meaningful scene from the sequence of scenes, representing the meaningful scene in written text using words and grammar appropriate to the reading level of the child, based on information stored in the data store, and providing the written text to a display device for presentation to the child.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The best way to understand and appreciate the subject invention is in conjunction with the attached drawings. The drawings are summarized briefly below and then referred to in the Detailed Description that follows.

[0018] FIG. **1** illustrates a Technology Assisted Reading Acquisition (TARA) system that enables literacy acquisition, in accordance with an embodiment of the subject invention.

[0019] FIG. **2** is a block diagram of an exemplary technology assisted reading acquisition (TARA) device, in accordance with an embodiment of the subject invention.

[0020] FIG. **3** provides a block diagram of a speech processing component that automatically recognizes a potentially meaningful experience that the child is having.

[0021] FIG. **4** provides a block diagram of a scene processing component that automatically recognizes a potentially meaningful experience that the child is having, in accordance with an embodiment of the subject invention.

[0022] FIG. **5** provides a block diagram of an evaluation component for computing and presenting written text for reading based on input from the speech processing and the scene processing components, in accordance with an embodiment of the subject invention.

[0023] FIG. **6** is a flow diagram that describes an overall method for receiving speech and scene information, analyzing the information, determining the appropriate written text to output to a visual display, and receiving feedback from users, in accordance with an embodiment of the subject invention.

[0024] FIG. **7** illustrates a caregiver and a child using the subject invention, in accordance with an embodiment of the subject invention.

[0025] FIG. **8** illustrates a room with a caregiver using the subject invention with a child, in accordance with an embodiment of the subject invention.

DETAILED DESCRIPTION

[0026] The drawings are now used to describe the subject invention, but it should be observed that it is possible to implement the innovation without these specific details. The description provides specific details to help the reader understand the invention.

[0027] Many of the terms used in this description, such as component and system, refer to computers, including their hardware and software. Other terms are specifically defined.

[0028] One objective of the invention is to create an environment for a developing child in which written text is constantly available and readable to enable the acquisition of written language automatically without the child's intention and without formal instruction.

[0029] Another objective of the invention is to exploit the rapid brain growth that occurs before a child is 6 years old by making written language constantly available to a child from soon after birth onward.

[0030] Another objective of the invention is to solve a previously believed unsolvable problem of providing a method for learning to read without formal instruction.

[0031] The present invention creates an environment for the developing child, or other illiterate person, in which written text is constantly available.

[0032] The present invention provides means of recognizing speech and scenes, objects, and actions and transforming this input into a written text form that can be appropriately displayed to a recipient who is not fully literate.

[0033] As used herein the following terms have the meanings given below:

[0034] Caregiver—means a person responsible for and interacting with a child. In the context of the present invention, caregiver also means a person who is talking and/or performing various actions.

[0035] Reader—means a person that is the intended recipient of written language text presented by the subject invention. In some cases, the reader may also be listening to or spoken to by a caregiver. In other cases, the reader may be looking at objects or scenes or engaged in a particular action. While in a preferred embodiment, a reader is typically a pre-literate child, the invention is not so limited.

[0036] Caregiver/Reader environment—means the acoustic, visual and other perceptual information relating to the interaction between the caregiver and reader. For example, the caregiver/reader environment includes the acoustic data from a caregiver or reader's speech, their facial movements and bodily gestures, and their physical environment.

[0037] Talker—refers to a person that is speaking within the caregiver reader environment. For example, a talker may be a caregiver, a reader or another person. The term "talker" is typically used when the identity of the person talking is not yet known by the system.

[0038] Sensor data—means encoded information or input data from a device that captures data, typically using a sensor. Example capture devices include inter alia a digital camera, digital camcorder, voice recorder, bar code reader, GPS, microphone, tablet computer, personal computer, laptop computer and mobile phone or smart phone. Sensor data is presumed to represent more generally the properties of an environment such as an aspect of a person talking, i.e. a caregiver or reader, or a caregiver/reader environment. Sensor data from a type of input device, such as a camcorder, is referred to as a channel of sensor data. The present invention not only supports multiple simultaneous channels of sensor data, it relies on multiple channels for accuracy of performance.

[0039] Utterance—refers to speech consisting of any of syllables, words, phrases, or sentences uttered by a person talking.

[0040] Scene—refers to a situation involving a caregiver and child or the child alone.

[0041] Meaningful experience—refers to the meaning for a reader inherent in a spoken utterance or a scene. If a meaningful experience is currently happening then it is referred to as a current meaningful experience.

[0042] Integration—refers to the combination of data from several components in order to achieve speech or scene recognition.

[0043] In one embodiment of the subject invention, modified written transcriptions of both the caregiver's speech and the reader's speech are displayed. The words and grammar of

these transcriptions are chosen to be appropriate to the perceptual, cognitive, and linguistic ability of the reader.

[0044] It may further be noted that in the case that a reader is a deaf child he/she might be at a disadvantage because he/she will not be hearing the spoken language from the caregiver corresponding to the written transcriptions. It should be noted, however, that the present innovation does not require that the reader hear speech in order to acquire written language.

[0045] Referring now to the drawings, FIG. **1** illustrates a Technology Assisted Reading Acquisition (TARA) system **100** that that enables literacy acquisition, in accordance with one embodiment of the subject invention. System **100** includes one or more input devices **106** that capture information from a caregiver and reader environment **104** including speech from a caregiver **102** and a reader **112**, as well as information about the scene and objects and actions therein. Each input device **106** provides one channel of sensor data as input to a TARA device **108**. Typically, a sensor data channel is a digital data stream from an input device **106** that provides a specific data type, such as digital audio or digital video. A channel of sensor data typically provides live, or real-time, information that in some way relates to speech from caregiver **102** and/or reader **102**, or information from caregiver/reader environment **104**, and even from an environment in which a caregiver is not present.

[0046] TARA device **108** is a computing device that typically includes a processor, memory for programs and data and permanent data storage. Examples of types of devices that may be employed as a TARA device include mobile devices, smart phones, tablet computers, personal computers, desktop computers, and server computers. In addition, the functions and components of TARA device **108** may be split across multiple computers as, for example, one worn by the caregiver and one worn by the reader, or additionally one in the room and one worn by the reader.

[0047] In addition to sensor data, TARA device **108** may obtain information from external data sources **114** such as information about caregiver **102** or reader **112**, the properties of caregiver and reader environment **104**, and more generally information to facilitate the operation of TARA device **108**.

[0048] TARA device **108** processes one or more channels of sensor data, obtains external data as necessary, identifies utterances or scenes, generates written text, appropriate to a reader **112**, and displays the written text on one or more output devices **110** that can be seen or otherwise perceived by reader **112**. Furthermore, TARA device **108** receives data from one or more reader input devices **116** that may include feedback or commands from either or both of reader **112** or caregiver **102**.

[0049] TARA device **108** interprets the speech of caregiver **102** and outputs text that is visually, orthographically, semantically, and syntactically appropriate to the age and comprehension level of reader **112**. In one embodiment, for example, the written output that the child sees might be a simplification of the spoken input. For example, the mother might say "Please give mom the toy." and the child might see "GIVE MOM TOY." In addition, the words might be presented one at a time at a slow rate.

[0050] In another embodiment, TARA device **108** can also process the speech of reader **112**. In this case, TARA device **108** processes utterances from reader **112** and presents appropriate modifications in written form. For example, if the child says, "Mm mah mme," the written presentation might be "MOMMY."

[0051] In one embodiment, reader **112** can issue commands using reader input devices **116**. For example, upon viewing some written text reader **112** might touch the display to indicate that he/she wishes to have the text displayed again, or have it spoken aloud.

[0052] FIG. **2** is a block diagram of an exemplary technology assisted reading acquisition (TARA) device, in accordance with an embodiment of the subject invention. Exemplary TARA device **108** includes a speech processing component **202** that receives and processes input data from one or more channels of sensor data output by one or more input devices **106**. Speech processing component **202** analyzes the input data to determine which utterance, if any, is the most likely. In one embodiment, this analysis uses an optimal integration of the multiple channels of sensor data, in a manner prescribed by Bayesian analysis or Fuzzy Logic, which gives a set of likely utterances along with a confidence measure of each utterance. As an example, facial and gesture recognition and other sensor inputs are utilized to enhance understanding of the auditory speech. In addition, this processing in conjunction with information obtained from a data store **208** provides information to determine relevance to the child's interests and goals, and even the current meaningful experience of the child.

[0053] Exemplary TARA device **108** also includes a scene processing component **203** that receives and processes input sensor data from one or more input devices **106**. Scene processing component **203** analyzes the input sensor data to determine which scene, if any, is the most likely. Analogous to the speech processing component, this analysis, in one embodiment, also uses an optimal integration, such as that prescribed by Bayesian analysis or Fuzzy Logic, which gives a set of likely scenes along with a confidence measure of each scene. Integration of multiple sensor inputs is utilized to enhance scene recognition, to determine relevance to the child's interests and goals, and even the importance of a current meaningful experience for the child.

[0054] TARA device **108** further includes an evaluation component **204** that receives the processed utterances from speech processing component **202** and processed scene data from scene processing component **203**, and translates this processed data into an appropriate written text output. The evaluation component **204** uses a variety of information sources from data store **208** to determine the words and grammar to be presented as well as the physical characteristics (font, size, color) of the written text. As described in more detail below, the information stored in data store **208** may include but is not limited to the age and reading level of various individuals including that of reader **112**, a characterization of perceptual, cognitive, and linguistic capabilities of individuals and of various reading levels, and presentation rules, such as text formatting and display rates, corresponding to different reading levels.

[0055] Evaluation component **204** provides formatted text to one or more output devices **110** for viewing by reader **112**.

[0056] Data store **208** stores any or all of sensor data, intermediate or partial results, information about caregiver **102** and reader **112**, as well as data and options provided using a control interface **210**. Data store **208** may be provided by virtually any mechanism usable for storing and managing

data, including but not limited to a file, a folder, a document, a web page or an application, such as a database management system.

[0057] Data store **208** may further represent a plurality of different data stores. For example, data store **208** may represent a presentation rule database, a cognitive database, and a vocabulary and grammar database. Further, data store **208** may also be provided by network storage or cloud storage in which the physical storage media is accessed across a network.

[0058] Control interface **210** refers to a user interface that enables an operator of TARA device **108** to select options and provide various types of control information. The operator of TARA device **108** may be caregiver **102**, reader **112** or another person or persons. Control interface **210** may be provided by a graphical user interface with a user interacting via a mouse, touch screen or other input device, or by physical controls on TARA device **108** such as switches, buttons, thumbwheels and the like.

[0059] TARA device **108** also receives inputs from reader input devices **116** connected to the evaluation component **204**. Reader input devices **116** enable reader **112** to provide feedback and to issue commands. Reader input devices may include a mouse, a keyboard, a touch screen or any other device that enables a user to provide information to TARA device **108**.

[0060] Now reference is made to FIG. **3**, which provides a block diagram of a speech processing component, in accordance with an embodiment of the subject invention. Speech processing component **202** receives and processes one or more channels of sensor data from input devices **106**.

[0061] Speech processing component **202** includes several sensor subsystems or components **302-306**, each of which receives a channel of sensor data and processes the sensor data. These sensor components include imaging component **302**, video component **304**, and audio component **306**.

[0062] Imaging component **302** processes incoming image sensor data, typically in the form of digital images in a standard format such as JPEG, from a digital camera or other image sensing device such as a mobile phone.

[0063] Video component **304** processes incoming video sensor data, typically digital frame data in a standard format such as MPEG2, MPEG4, or AVI from a camcorder, digital video camera, or smart phone.

[0064] Audio component **306** processes incoming audio sensor data, typically in the form of a standard analog or digital format from a microphone, voice recorder, or other similar device.

[0065] A speech component **308** processes any speech input captured by the imaging, video, and audio components. As described elsewhere, the main task performed by speech component **308** is automated speech recognition (ASR).

[0066] An optical character recognition (OCR) component **310** processes imaged text captured by the image component **302** and/or the video component **304**, for example, to obtain written information. In one embodiment, a caregiver might be reading a book to a child, the text of the book is recognized via optical character recognition, and a modified form of the text is provided to a display device.

[0067] A search component **312** is provided that performs searches to improve the accuracy of the speech component. The search component accesses information about the talker, the characteristics of the talker's or similar talkers' speech, and algorithms for recognizing utterances. The information for the search is stored in data store **208**.

[0068] Gesture component **314** processes the gestures of a person in caregiver and reader environment **104**, as captured by imaging component **302** and/or video component **304**. In a preferred embodiment, gestures of a talker are tracked to determine which person is most likely talking. This is used as an input to automated speech recognition performed by the speech component. In addition, different types of gestures used by the talker can be an additional source of information to help disambiguate what is actually being said.

[0069] A location component **316** determines the geographic location of caregiver **102**, and/or the reader **112**. In one embodiment, location information is used to determine whether the caregiver or reader is talking, and therefore, improve the accuracy of the spoken language. Location component **316** may use global positioning system (GPS) technology, and/or other suitable location technologies.

[0070] Bar code component **318** processes bar codes that are made available by the imaging and/or video components. In a preferred embodiment, a bar code attached to an object or to a person is decoded to obtain a description of the object or person's identity. This information can then provide contextual information that may be used in performing automated speech recognition.

[0071] Head tracking component **320** tracks head position captured by the imaging and video components. Determining the head and/or mouth movements of the talker can facilitate automated speech recognition.

[0072] Mouth tracking component **322** tracks mouth position and movements captured by the imaging and video components. In one embodiment, mouth positions, which are systematically related to different utterances, are used to in performing automated speech recognition.

[0073] An emotion component **324** analyzes image, video and audio input data to extract emotion content. Automated emotion recognition follows a very similar algorithm as that used in automated speech recognition. There are identifiable signatures in the sensor inputs that characterize different emotions, which can be retrieved by search component **312**, and used to improve emotion recognition.

[0074] An integration component **326** integrates or combines all of the information captured by the imaging, video, and audio components and processed by the other components. In one embodiment, an optimal integration, such as that prescribed by Bayesian analysis or Fuzzy Logic, is used. Combining all available components in this manner typically improves the accuracy of utterance recognition by speech processing component **202**.

[0075] FIG. **4** provides a block diagram of a scene processing component **203**, in accordance with an embodiment of the subject invention. Analogous to speech processing component **202**, scene processing component **203** receives and processes one or more channels of input sensor data, to assist with automatic recognition of the child's meaningful experience.

[0076] Imaging component **402**, video component **404**, and audio component **406** operate identically to their respective counterparts in FIG. **3** and have the same descriptions given in reference to FIG. **3**.

[0077] A speech component **408** processes any speech input captured by the imaging, video, and audio components. In a preferred embodiment, who is talking and what is being said is used to facilitate scene processing.

[0078] An optical character recognition (OCR) component **410** processes imaged text captured by the image component **402** and/or the video component **404**. For example, text from a posted sign could be used to facilitate recognition of an object and/or a scene.

[0079] A search component **412** is provided that performs searches to improve the accuracy of the scene processing component. Some of the information for the search may be stored in data store **208**. Search component **412** obtains information about typical scenes, objects, and actions that is used integration component **436** to recognize the most likely current meaningful experience of reader **112**.

[0080] Gesture component **414** processes user gestures as captured by imaging component **302** and/or video component **304**. In a preferred embodiment, gestures of persons are tracked to facilitate the recognition of the scene, objects, and actions which in turn improves recognition of the most likely current meaningful experience of reader **112**.

[0081] A location component **416** determines the geographic location of caregiver **102** and reader **112**. Location component **416** may use global positioning system (GPS) technology, and/or other suitable location technologies. For example, location component **416** can indicate whether the caregiver and child are side-by-side or in separate locations in the room. This information is then used by scene processing component **203** to determine whether or not the child's current meaningful experience is being shared with the caregiver.

[0082] Bar code component **418** processes bar codes that are made available by the imaging and/or video components. In a preferred embodiment, a bar code may be attached to an object or to a person that encodes identity information. This information can then be used to improve the accuracy of the scene processing system. Also, the encoded bar code information can be presented in an appropriate written form to reader **112**.

[0083] Head tracking component **420** tracks head position captured by the imaging and video components. Determining the head and eye fixation of reader **112** is important information about the current meaningful experience of reader **112**. As an example, if it is determined that reader **112** is looking directly at a toy red car, the written words TOY CAR or RED CAR might be displayed.

[0084] Eye tracking component **422** tracks eye fixation position and movements captured by the imaging and video components.

[0085] An emotion component **424** analyzes image, video and audio input data to extract emotion content. Automated emotion recognition contributes to scene processing. In one embodiment, emotion is analyzed and is used to determine the presentation format to use for written text that represents the emotion in the current meaningful experience. For example, a high valence, or high activity, event, such as a caregiver dancing might result in the written word DANCE being displayed in a red vibrating font. A low valence, or low activity, event such as a caregiver sleeping might result in the written word SLEEP being displayed in a steady blue font.

[0086] Analogous to integration component **326** in FIG. **3**, integration component **426** integrates or combines all of the information captured by the imaging, video, and audio components but in this case for scene processing. Information provided by components of scene processing component **203** are integrated to recognize the child's most likely current meaningful experience. It may be appreciated that each of input devices **106** may capture information from caregiver and reader environment **104** independently. Thus, each sensor data stream represents a set of possible alternatives for the child's current meaningful experience. Integration component **426** combines or integrates these to provide a set of possible alternatives for the child's current meaningful experience. Each of the alternatives is weighted according to a degree of confidence that it is meaningful, in the case of speech, or significant, in the case of scene. This analysis involves an optimal integration, carried out by integration component **426**, such as that prescribed by Bayesian analysis or Fuzzy Logic, which analyzes the set of likely alternatives along with a confidence measure of each alternative. If a confidence assigned to a given alternative exceeds a preset threshold value, then the corresponding alternative is mapped into a meaningful utterance or a significant action.

[0087] FIG. **5** provides a block diagram of an evaluation component **204** for computing and presenting written text for reading based on input from speech processing component **202** and scene processing component **203**, in accordance with an embodiment of the subject invention. Evaluation component **204** receives input from speech processing component **202** and scene processing component **203** and analyzes these inputs to determine a best guess for the current meaningful experience for reader **112**. It generates an appropriate written rendition of this meaning and provides it to one of output devices **114** for viewing by reader **112**.

[0088] Evaluation component **204** separately processes speech inputs from speech processing component **202** and scene information from scene processing component **203**. For example, for speech processing, evaluation component **204** includes a talker detection component **502** that determines which of caregiver **102**, or reader **112** is talking or if another person is talking. For scene processing, talker detection component **502** determines whether the caregiver, child, or another person is performing a significant action.

[0089] For speech processing, an analysis component **504** determines which utterances are possible given input from speech processing component **202**. Analysis component **504** also computes a confidence value for each of the possible utterances. For scene processing, analysis component **504** determines which actions are possible and computes a degree of confidence for each possible action.

[0090] A written text component **506** receives encoded utterances or encoded actions from analysis component **504** and determines the actual words to be presented. No words are determined if none of the confidence values corresponding to the utterances or actions provided by analysis component **504** fall below a confidence threshold. Written text component **506** uses information about reader **112**, maintained in data store **208**, to determine the most appropriate words and grammar for reader **112**. For example, analysis component **504** may determine that a possible utterance with a high confidence value is that caregiver **102** is showing an eight-month-old reader **112** a red toy car. In this case written text component **506**, using information about reader **112**, specified in data store **208**, determines that only the word CAR should be provided to output devices **110** for display. If the child were 14 months old, on the other hand, the written text component might determine that the words TOY CAR should be provided to output devices **110** for display.

[0091] Table 1, below, provides an example list of reader characteristics that may be used to determine what words and grammar to present after determination of a meaningful utterance or a significant action. Although the rules are based on

age and reading level, the actual determination is also based on the perceptual, cognitive, and linguistic characteristics of the child, which will vary across different children.

[0092] As described herein, written text component **506** uses information stored in data store **208** about the individual caregiver, child, and situation to determine the actual words to be presented. In the first year or so of life, children tend to speak single word utterances. Single word displays might thus be most optimal to present. As the child's linguistic competency develops, the written displays are made more complex in terms of the number of words presented and their grammatical structure. In one embodiment this information is summarized as rules. An example set of such rules is given below in Table 1.

TABLE 1

Rules for determining words and grammar appropriate for a reader.

Reader Age/Reading Level	Words and Grammar Characteristics
6-12 months/Novice	Single Words or Syllables Only Content Words Presented
13-18 months/Less Novice	Multiple Words or Syllables Only Content Words Presented
19-30 months	Multiple Words or Syllables Content Words and some Function Words Presented
31-42 months	Multiple Words or Syllables Content Words and some Function Words Presented
43-54 months/Near Expert	Multiple Words Most Words Presented Fairly Short Presentation Duration
55-66 months/Expert	Multiple Words All Words Presented

[0093] A formatting component **508** determines the characteristics of the letters and words to be displayed. Formatting component **508** uses information about reader **112**, obtained from data store **208**, to determine the most appropriate format for reader **112**. Following the previous example, written text component **506** specifies that only the word CAR should be provided as output on the display. Using information about the child specified in data store **208**, formatting component **508** may determine that the word "car" should be written in large, dynamic, colored, uppercase letters on the display in the child's range of view. This dynamic colorful display is meant to capture and maintain the child's attention to the written text. If reader **112** is 14 months old, however, written text component **506** may specify that the two words TOY CAR should be presented. Formatting component **508** might analogously determine that the two words should be presented successively one word at a time for a duration of 1 second per word. The words might also be presented in simple black uppercase letters. As illustrated herein, TARA device **108** adapts the written presentation to the putative reading level of the reader **112**, using information about the child specified in the data store **208**.

[0094] Formatting component **508** uses information stored in data store **208** about the individual caregiver, child, and situation to determine the visual properties of the letters that make up each word, the number of words presented in the display, the rate of presentation of successive displays containing the written output. The display of written language is chosen to conform to the perceptual, cognitive, and linguistic constraints of the child. For example, in the first month of life, a child can distinguish only the top letter on a reading chart but reaches near adult levels by 8 months. Infants' temporal resolution (the identity and order of changing images) is also well below that of adults. These constraints, or rules, are used to determine the size and duration of characters to be presented to children of different ages and different perceptual, cognitive and linguistic levels.

[0095] Formatting component **508** also determines from a child's reading level that perhaps a sequence of words (or perhaps syllables or phrases) should be presented successively on a single line in a fixed window.

[0096] If temporally successive letters, syllables, or words are presented one after another in a fixed reading window, the rate of presentation may be adapted to the perceptual capabilities of the child. Given that children read more slowly than adults, the rate of presentation for the targeted readers would be about 1 word per second. A literate adult would be capable of reading the words at 4 times this rate. In one embodiment, such information is formulated as a set of rules, stored in data store **208**, and is used by formatting component **508** to determine the appropriate display parameters for a given child.

[0097] Although it is expected that children will learn about letters by simply seeing written words, formatting component **508** also provides options to embellish the written text with font, size, and color differences. As examples, consonants might be one color and vowels another, nouns and verbs could be different sizes, and closed grammatical categories (e.g., prepositions) could be presented in different type fonts. In addition, words might be segmented into syllable boundaries, separated by hyphen signs, or presented one syllable per display. The various options may be stored in data store **208** and used by formatting component **508** along with child-specific information that would be automatically learned and updated, or entered by a person operating TARA device **108**.

[0098] In addition, formatting component **508** may issue commands to accompany or precede written text by an auditory signal and/or a visual pulsating pattern on the display to capture the attention of reader **112**.

[0099] Table 2, below, gives examples of formatting rules for each of the first five years of a child's life that may be applied in determining the presentation of the written text. For example, a younger less experienced child would be shown larger and more colorful fonts at a slower rate of presentation.

TABLE 2

Formatting rules for determining presentation of written text.

Reader Age/Reading Level	Presentation Characteristics
6-12 months/Novice	Use only uppercase letters Very Large Font Dynamic Display of Letters Colorful Letters Narrow Reading Window Long Presentation Duration
13-18 months/Less Novice	Use only uppercase letters Large Font Dynamic Display of Letters Colorful Letters Narrow Reading Window Long Presentation Duration
19-30 months	Large Font Dynamic Display of Letters Colorful Letters

TABLE 2-continued

Formatting rules for determining presentation of written text.

Reader Age/Reading Level	Presentation Characteristics
	Narrow Reading Window
	Long Presentation Duration
31-42 months	Large Font
	Less Dynamic Display of Letters
	Less Colorful Letters
	Less Narrow Reading Window
	Shorter Presentation Duration
43-54 months/Near Expert	Somewhat Smaller Font
	More Static Display of Letters
	Fairly Plain Letters
	Wider Reading Window
	Fairly Short Presentation Duration
55-66 months/Expert	Smaller Font
	Static Display of Letters
	Plain Letters
	Wide Reading Window
	Short Presentation Duration

[0100] In the case that multiple output devices **110** are in use, a display selection component **510** selects one of output devices **110** on which to present written text to reader **112**. In one example, scene processing component **203** may have determined that the reader **112** is in the vicinity of one physical display rather than another. Thus, the display selection component **510** would use this information to select the display near the child. If the caregiver, for example, is carrying a portable computing device for either automated speech processing and/or scene processing, it would be straightforward to have the text presented on its display screen. The screen could be held in place by a light-weight vest that the caregiver would wear, and easily seen by the reader **112**. It is also possible for caregiver **102** or another user, using control interface **210**, to manually select which display will be used to present the appropriate written text.

[0101] A reader feedback component **512** accepts inputs from reader input devices **116** and responds appropriately. For example, reader feedback component **512** may allow reader **112** to interact with the written text by touching or otherwise manipulating the output display. As an example, the output display might have a touch-sensitive display which allows the child to touch it to issue a command to re-display text. Other controls may enable reader **112** and/or the caregiver **102** to perform other manipulations that can vary the written presentation and/or to include other sensory inputs such as associating the written language with spoken or sign language.

[0102] FIG. **6** is a flow diagram that describes an overall method for receiving speech and scene information, analyzing the information, determining the appropriate written text to output to a visual display, and receiving feedback from users, in accordance with an embodiment of the subject invention. In one embodiment, steps **602-612** on the left of the diagram are performed by speech processing component **202** in parallel with the processing of steps **614-626** by scene processing component **203**. In other embodiments only speech processing component **202** or scene processing component **203** may be operational at a given time.

[0103] At step **602**, sensor data is received from one or more of input devices **106** by speech processing component **202**. At step **604**, an utterance is identified **604** from the sensor data input. At step **606** a determination is made as to whether the identified utterance is meaningful.

[0104] In one embodiment, if the utterance is determined to be meaningful then a modified written version of it will be presented on one of output devices **110**, whereas if it is determined not to be meaningful the utterance is discarded. Thus, in this embodiment, further steps are only performed for a meaningful utterance, i.e. an utterance that is determined to be meaningful at step **606**.

[0105] At step **608** the identity of the talker, i.e. the person speaking, is determined. At step **610** the emotion of the meaningful utterance is assessed. At step **612** the meaningful utterance is represented in written language text. This representation is the best guess of TARA device **108** as to the meaning of the utterance.

[0106] At step **614**, sensor data is received from one or more of input devices **106** by scene processing component **203**. At step **618** any action currently occurring in the scene is identified. At step **620** a determination is made as to whether a current action identified in step **618** is significant. In one embodiment, if the action is determined to be significant then an appropriate written description of it will be presented on one of output devices **110**, whereas if it is determined not to be meaningful the action is discarded. Thus, in this embodiment, further steps are only performed for a significant action, i.e. an action that is determined to be significant at step **620**.

[0107] At step **624**, any emotion present in the significant action is assessed. Then, at step **626**, the significant action is represented in written language.

[0108] In one embodiment, processing steps **628-638** are initiated by determination of either or both of a meaningful utterance or a significant action. At step **628** the words and grammar, for either or both of a previously determined meaningful event or significant action, are generated at a level appropriate to the perceptual, cognitive, and linguistic capabilities of the identified reader **112**. At step **630** the presentation format of the words and grammar generated at step **628** are determined. At step **632**, one or more of output devices **110** are selected on which to display the written text. At step **634**, the written text is provided to the selected output device. At step **636** feedback is received from one or more of reader input devices **116**. A response to the feedback is provided, if appropriate, at step **638**.

[0109] FIG. **7** illustrates a caregiver using the subject invention with a child, in accordance with an embodiment of the subject invention. In the example, text is output from TARA device **108** to an augmented head-up display **702** appearing in FIG. **7** as glasses worn by a child in which the text is superimposed on the normal view of the scene. A caregiver is saying "Please give mom the toy." and the processed text output by TARA device **108** to the glasses is "GIVE." In this example, two microphones **704** embedded in the temple of the head-up display serve as input devices **106**. In this embodiment output device **110** is worn by the child, i.e. by reader **112** who is a child in this example.

[0110] FIG. **8** illustrates a room with a caregiver using the subject invention with a child, in accordance with an embodiment of the subject invention. In this example, output device **110** is a projection display on the wall of the room to be read by reader **112**, the child. The child is saying "Mm mah mme," and is also seeing the written text "MOMMY" on the projection display. Two video cameras with microphones are shown attached to the upper corners of the wall.

[0111] Given the above description with hypothetical examples, it is understood that persons skilled in the art will agree that there are several embodiments that follow the methods, devices and systems described.

What is claimed is:

1. A computer-implemented method for enabling a child to learn to read, comprising:

maintaining a data store with information that characterizes the reading capabilities of children;

receiving a stream of sensor data from one or more input devices, said sensor data representing the speech of a person speaking, said person being either an adult first person, or a child second person;

identifying a meaningful utterance from the stream of sensor data;

determining the identity of the child;

representing the utterance in written text using words and grammar appropriate to the reading level of the child, based on information stored in the data store; and

providing the output text to a display device for presentation to the child.

2. The method of claim **1**, wherein said information that characterizes the reading capabilities of children includes rules to apply to text based on the age or reading level of a child and said representing the meaningful utterance in written text is based in part on said rules.

3. The method of claim **1**, wherein said information that characterizes the reading capabilities of children includes rules for formatting text based on the age or reading level of a child, further comprising determining the presentation format of the written text based on said rules for formatting text and providing said presentation format along with the written text to the display device.

4. The method of claim **3**, further comprising:

assessing the emotion in the meaningful utterance; and

additionally basing said determining the presentation format on the assessed emotion in the meaningful utterance

5. The method of claim **1**, further comprising selecting said display device from a plurality of display devices.

6. The method of claim **1**, further comprising receiving commands from the first person or the second person.

7. The method of claim **1**, wherein said sensor data includes image data describing visual characteristics of the physical surroundings of the first person and second person, further comprising:

performing bar code detection on the image data to detect a bar code; and

including a text description of information encoded in the bar code in said written text.

8. The method of claim **1**, wherein said sensor data includes a sequence of images that represent the person speaking, further comprising:

performing face and gesture recognition on the stream of images to identify the speech of the person speaking; and

determining the identity of the person speaking, said determining based in part on the identified speech.

9. A computer-implemented method for enabling a child to learn to read, comprising:

maintaining a data store with information that characterizes the reading capabilities of children;

receiving a stream of sensor data from one or more input devices, said sensor data representing a sequence of scenes, each scene including a child;

identifying a meaningful scene from the sequence of scenes;

determining the identity of the child in the meaningful scene;

representing the meaningful scene in written text using words and grammar appropriate to the reading level of the child, based on information stored in the data store; and

providing the written text to a display device for presentation to the child.

10. The method of claim **9**, wherein said information that characterizes the reading capabilities of children includes rules to apply to text based on the age or reading level of a child and said representing the meaningful scene in written text is based in part on said rules.

11. The method of claim **9**, wherein said information that characterizes the reading capabilities of children includes rules for formatting text based on the age or reading level of a child, further comprising determining the presentation format of the written text based on said rules for formatting text and providing said presentation format along with the written text to the display device.

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

assessing the emotion in the meaningful scene; and

additionally basing said determining the presentation format on the assessed emotion in the meaningful scene.

13. The method of claim **9**, further comprising selecting said display device from a plurality of display devices.

14. The method of claim **9**, further comprising receiving commands.

15. The method of claim **9**, wherein said sensor data includes image data, further comprising:

performing bar code detection on the image data to detect a bar code; and

including a text description of information encoded in the bar code in said written text.

16. The method of claim **9**, wherein said sensor data includes image data, further comprising:

performing optical character recognition on the image data to detect text; and

including the detected text in said written text.

17. The method of claim **9**, wherein said sensor data includes a sequence of images, further comprising:

performing gesture recognition on the sequence of images to identify gestures performed by at least one person in at least one of said sequence of scenes;

determining, based at least in part on said identified gestures, the identity of the at least one person; and

determining at least one action corresponding to the identified gestures of the at least one person.

18. The method of claim **1** or **9**, wherein at least one of said input devices is selected from the group consisting of a digital video camera, a digital camera, and a microphone.

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