A Behavioral Programming Approach to the Design-Development of Humanoid Robots

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ABSTRACT

An introduction to a radical new approach to solving the many challenges of artificial intelligence (AI) in humanoid robotics. Through the use of a Relational Robotic Controller (RRC) and Relational Correlation Sequencer (RCS) modules, including a self-location and identification coordinate frame, behavioral programming techniques may be employed to achieve human-like levels of AI for the identification, recognition, visualization, and comprehension of the input signals. Behavioal programming techniques may also be applied to the auditory signals and the control of the verbal-phoneme sound generator, to achieve human-like levels of AI for the declarative-verbal capabilities of the humanoid robot. The approach described herein represents a paradigm shift in today's analytical-programming methodology.

Key words: human-like artificial intelligence; humanoid robots; Thinking machines; behavioral-programming; behavioral speech processing.

Acknowledgment: The authors are grateful to MCon Inc. for allowing us to publish their proprietary data, which was accumulated during the past 20 years. This paper presents an overview/introduction to the design of smart RRC-humanoid Robots. The reader may obtain technical details relating to the design in the references included in this paper. Also the authors are planning the presentation of technical details in two follow-on papers, at the Humanoid Robotic Conference to be held later this year. The two papers will describe the behavioral-programming approach for the visual and auditory RRC-humanoid Robots.

Introduction: By the 1950's the theoretical foundation for Artificial Intelligence (AI) had been established (Turing, 1950, 1953), and Alan Turing, arguably, the founder of AI, posed the question: "When is a machine thinking?" More than 60 years later, this question has not been answered satisfactorily. In the discipline of AI, the question may be reworded to: "When does a machine display human-like levels of AI?"

Alan Turing's approach to an answer was in terms of the behavior of the machine. He devised a "Turing test" based on the conversational behavior of the machine; and deemed any machine that passed the test to be a thinking machine (Turing, 1953, Rosen 2007).

In this paper we describe a building path for a machine that can reach human-like levels of AI, defined in terms of the behavior of the machine. It describes a behavioral programming approach for the design of a smart RRC based humanoid robot, called a RRC-humanoid robot. The RRC-humanoid robot is a human-like robotic system, controlled by a proprietary Relational Robotic Controller (RRC) (Rosen, 2003, 2006a,b,c).

But first, a note about human-like levels of AI:

1. Human intelligence is experiential intelligence. Humans learn from, and remember their experiences throughout their lifetime. A behaviorally programmed RRC-humanoid robot emulates the experiential intelligence of a human.
2. Humans have a self-location and identification coordinate frame that is trained from infancy to give the human brain a proprioceptive self-knowledge capability. Even a baby, with a self-knowledge capability, instinctively knows the location of every surface point on its body; the location of its flailing limbs; and by extension, the location of every coordinate frame point in the near space defined by its flail-

ing limbs. The fundamental design characteristic of the RRC-humanoid robot is a centralized hub of intelligence, a proprietary module that is the centralized “self location and identification” coordinate frame of the system. This module gives the RRC-humanoid Robot a robotic form of proprioceptive knowledge, similar to human proprioceptive intelligence. In the RRC-robot, the self-knowledge capability is the basis for all knowledge.

3. In order to achieve contextual, or “self knowledge” of visual data, auditory data, olfactory data, gustatory data, and vestibular data, all the data obtained from those other human sensors must be related and correlated with the self knowledge, self location and identification coordinate frame.

4. The human brain relates, correlates, prioritizes and remembers sensory input data. Similarly, relating, correlating, prioritizing and remembering input patterns must be the essential analysis tool required to achieve human-like intelligence. Most robotic computers are designed to calculate, compute and solve problems related to sizes, distances, shapes, and colors of objects recorded in the FOV of the visual system or sensed by the other sensors.

5. Human intelligence is gained only from the 6 external sensors: tactile, visual, auditory, olfactory, gustatory, and vestibular sensors. These sensors provide for the consciousness associated with human "feeling," "seeing," "hearing," “smelling,” "tasting," and “balancing.” The recording monitors of the RRC-humanoid Robot emulate the external sensors of humans.

6. In a smart RRC-humanoid Robot, the mechanical robotic body and associated sensors simulate the human body and the human sensors. Also the control system operates in a manner similar to the human brain; that is, by relating and correlating the input data rather than computing and calculating distance, size, and shape.

The Visual and Auditory RRC-humanoid Robots:

The mechanical robotic system: In a smart RRC-humanoid Robot the mechanical system is made up of a human-like robotic body, bipedal limbs, power source, and motors and gears required to move the body, limbs, arms, hands, and fingers.

Sensory recording monitors: The human-like recording monitors are those that simulate the six human external sensors: tactile, vestibular, visual, auditory, olfactory and gustatory. The recording monitors are the data-gathering portions of the RRC-humanoid Robot. The sensory recording monitors consist of pressure transducer sensors (tactile), vestibular (balance) sensors, video/visual sensors (simulating the human eyes), microphones (simulating the human ears), and sound/phoneme generators to give the robot a verbal speech capability. All intelligence in the system is gained experientially (behavioral programming) by processing/programming the input data obtained from the recording monitors identified above.

A Relational Robotic Controller (RRC): The RRC (Rosen A, & D.B. Rosen, 2003, 2006a,b,c) is used to control the motors and verbal phoneme sound generator of the mechanical robotic system. Note that the design of the RRC was reverse engineered to operate like the human brain, based on the assumption that the human brain relates, correlates, prioritizes and remembers rather than computes and solves problems. An RRC consists of sets of Relational Correlation Sequencer (RCS) modules and associated memory units called Task Selector Modules (TSMs), which operate by relating and correlating input signals and prioritizing and remembering important correlations.

Behavioral programming and the development of human-like AI:

Behavioral programming is achieved by training the humanoid robot to control its body, limbs, and verbal-phoneme sound generator on the basis of input data from the six external sensors. It is an experiential supervised programming technique analogous to the autonomous learning of a human. Behavioral programming techniques are employed for all the sensory input signals of the humanoid robot.

For example, the tactile input signals are used to define the central hub of intelligence, the self nodal map/coordinate frame, of the humanoid robot. The behavioral programming technique employed for the self location and identification “self knowledge” coordinate frame is an itch scratch methodology, wherein the robot is fully trained and remembers how to a) reach and touch (scratch) all points located on the sur-

face of the robotic body, and all points in the near space surrounding the robotic body, b) to identify and locate all such points, and c) to identify and locate all the “end joint” body parts (ends of fingers, elbow, knee etc) used to scratch all the itch points. When the level of training reaches the threshold of “self Knowledge,” the self nodal map and associated TSMs will facilitate the robotic identification and recognition of all body parts, and the navigation of all moveable parts of the robot towards any and every itch point located on the surface of the robotic body and all points in the near space surrounding the robotic body.
The totality of the programmed “self location and identification” data, stored in a TSM-memory module, is the basis for the “self Knowledge” level of intelligence. Analogous to the proprioceptive knowledge of a human, a RRC-robot with a fully programmed “self knowledge” capability “knows,” behaviorally, the location of every surface point of the robotic body, the location of flailing limbs, and by extension, the location of every coordinate frame point in the near space defined by flailing limbs.

In the visual and auditory RRC-humanoid systems, experiential intelligence is obtained by performing behavioral programming on the processed raw data coming from the video visual recording monitor and the auditory recording monitor. The raw data is processed in an interface circuit, inputted to the RRC and then behaviorally programmed to reach human-like levels of AI. Behavioral programming reaches the level of experiential human-like intelligence, when the RRC-humanoid robot demonstrates behaviorally that it has “identified, recognized, visualized and comprehended in the same manner as does a human, the signals coming from the visual sensors, or the auditory sensors. The following sections will describe the processing of the raw data in the Interface Circuit, and the behavioral programming of the processed data within the RRC-humanoid robot. On completion of behavioral programming, the RRC-humanoid Robot demonstrates behaviorally human-like levels of AI for the identification, recognition, visualization or comprehension of the processed raw data.

Processing the visual raw data in the interface circuit and behaviorally programming the processed data.

The Interface Circuit stage: The visual raw data consists of the output of the two CCD arrays of the 2-video visual cameras of the visual recording monitor. This data is inputted to the Interface circuit. The interface circuit generates a real time 3D-photometric image that is a high fidelity representation of the real objects that gave rise to that image. The interface circuit includes a processing stage for the calibration and projection of the 3D-photometric image onto the self-location and identification Nodal Map Module, the centralized “self knowledge” coordinate frame of the system.
Behavioral programming of the calibrated 3D-photometric image: Once the 3D-photometric image is calibrated and projected onto the self-knowledge Nodal Map Module of the RRC, The RRC-humanoid Robot is behaviorally programmed to control body and limbs, and the verbal phoneme sound generator in relation to the 3D-photometric image. The following aspects of the 3D photometric image are identified, recognized, visualized, and comprehended by generating different words by the verbal phoneme sound generator or undertaking distinguishing body or limb actions based on the 3D-photometric image:

- The rainbow of colors between the 4000 Angstrom- purple and the 8000 Angstrom-red,
- All objects in the field of view of the robotic system, and
- All shapes, forms and colors of the 3D-objects in the field of view of the robotic system.

The identification, recognition, visualization and comprehension of all objects, shapes, colors, and forms is achieved behaviorally. The RRC-robot behaviorally moves its body, limbs, and controls its verbal phoneme sound generator so as to distinguish the various identifications, recognitions, visualizations and comprehension of all objects in the FOV of the visual system.
Note: Behavioral-programming of the Auditory RRC-humanoid Robot generates an operational definition of the “identification”, “recognition” and “comprehension“ levels of AI. Any human need merely “verbally ask” the RRC-robot to identify, recognize, comprehend, or visualize any color or 3D-object in the FOV, in order to obtain a response that is indistinguishable from the response of another human.

For example: A person can hold an "apple" in front of the Robot and ask the Robot to "Identify the object I am holding in front of you." A fully programmed Auditory RRC-humanoid Robot will respond: "That is an Apple." The robot could also demonstrate comprehension of the image by responding verbally with encyclopedic data relating to the object, etc.

Processing the auditory raw data in the interface circuit and behaviorally programming the processed data.

The Interface Circuit stage: The auditory raw data consists of the output of the sound receiving microphones that simulate the human ear. When a talking sound is applied to the ear-like receiving microphones, they generate a sequence of frequencies and amplitudes as a function of time. These frequencies and amplitudes may be illustrated in an amplitude-frequency-time (a-f-t)-diagram. This (a-f-t) data is inputted to the Interface Circuit. The Interface Circuit processes the a-f-t data into collective modalities that have been selected to be characteristic of 120 phoneme-sound combinations present in the English language.

The interface circuit also performs behavioral speech processing on sequential sets of phoneme sounds and identifies and recognizes these sequential sets as " words" or "sentences" formed by the person speaking to the microphones of the auditory recording monitor. (Note: The behavioral speech processing performed in the Interface circuit stage is described in the next section). In addition the (a-f-t) data must be formatted within the Interface circuit so that it is compatible with the RRC- phoneme sound generator and the input to the RRC-multidimensional Nodal Map Module (Rosen A, & D.B. Rosen, 2003, 2006a,b,c).

In addition to the formation of words and sentences, the Interface stage processes the following aspects of the input sound signal:

• First, all sound frequencies from zero to 20,000 cps.

• Second, with the aid of a spectrum analyzer, collective modalities that are tuned to the phoneme sound combinations in the English language, to musical sounds or to environmental noise.

• Third, the RRC-humanoid robot may be programmed to develop high levels of human-like AI by relating verbal words, music or environmental noise to other sensory data.

The final output of the Interface circuit stage: The "words and sentences," music or environmental noise is inputted to their respective multidimensional Nodal map Modules of the RRC-humanoid Robot, for behavioral programming.

Behavioral programming of the words and sentences inputted to the RRC-multidimensional nodal map module: Once the words and sentences are projected to the multidimensional RRC nodal map module, the RRC-humanoid Robot is behaviorally programmed to control body and limbs, and the verbal phoneme sound generator in relation to the words and sentences applied to the multi-dimensional nodal map module. The following aspects of the words and sentences are identified, recognized, visualized, and comprehended by generating different words by the verbal phoneme sound generator or undertaking distinguishing body or limb actions based on the words or sentences applied to the multidimensional RRC nodal map module. 1. Training to repeat, read, and write phoneme-sound based words and sentences by relating and correlating the acoustic content with the visual image represented by the signals. 2. Training the robot to comprehend the meaning of a "heard" word. 3. Training to verbally describe experiential sensory data obtained from the visual, tactile, olfactory or gustatory sensors. 4. Training the robot to get into a "conversational Mode," 5. Training the robot to respond to commands, etc.

Speech processing by Behavioral Programming the Auditory RRC-Humanoid Robot:

Recognizing the acoustic sequential set of phoneme-signals as phonetic words and sentences.

The problem:

The problem of converting the perceived acoustic spectrographic (a-f-t) properties of language into an identifiable phonetic structure is an ill posed problem, similar to the inverse optics problem (Marr, D (1962). There is not a simple one to one mapping between the acoustic properties of speech and the phonetic structure of an utterance. Co-articulation (the segmentation problem) is generally identified as the major source of the problem. Co-articulation gives rise to difficulty in dividing the acoustic signal into discrete “chunks” that correspond to individual phonetic segments and a lack of invariance in the acoustic signal associated with any given phonetic segment.

Note: the usual methodologies for solving the problem includes lexical segmentation processing (co-articulation), word recognition processing, interactive-activation processing, context effect processing, syntactic effects on lexical access processing, lexical information and sentence processing, syntactic processing and intonation-structure processing.

The Behavioral speech processing methodology for solving the inverse auditory problem: Because of the complexity in the mapping between the acoustic signal and phonetic structure, an experiential, behavioral programming methodology was developed for “unpacking” the highly encoded, context dependent speech signals. “Unpacking” is performed by programming the RRC to repeat and “remember” (in the TSM-memory modules) the “heard” words and sentences of multiple speakers. Further “unpacking” is performed by associating and calibrating the heard verbal speech with the corresponding visual and tactile data obtained in the visual and tactile coordinate frames in which the robot is operating. Finally, the robot is trained to be sensitive to such factors as acoustic phonetic context, speaker’s “body language,” speaking rates, loudness and “emotion laden” intonations.

The auditory RRC-humanoid Robot takes into account the acoustic consequences of such variations when mapping the acoustic signal into the phonetic structure. The problems of speaker’s “body language,” “emotion laden” intonations, acoustic phonetic context, speaking rates, and loudness is solved by the auditory RRC by coordinating the search engines of the visual and tactile systems with the search engine of the Auditory RRC-humanoid Robot.

Innovative features of RRC-humanoid Robots: How the invention differs from, and is an improvement over what currently exists.

Present day humanoid robots have never before been programmed with human-like AI that includes human-like identification, recognition, visualization and comprehension of a) the words and sentences ”heard” by an auditory RRC-humanoid Robot, b) the full array of sizes, distances, shapes, and colors of objects recorded in the FOV of the Visual RRC-humanoid Robot, and c) a capability to respond verbally and intelligently to the queries or statements spoken by humans, or the visual signals observed by the robot. The RRC-humanoid Robot does so because of innovative features that have been incorporated into the system. The following description of innovative features is divided into 3 parts; Part 1 describes innovative features that are common to the visual and auditory RRC-humanoid system. Part 2 describes features associated with the Visual-RRC-humanoid robot. Part 3 describes features associated with the Auditory-RRC-humanoid Robot.

Part 1-Innovative features common to the visual and auditory RRC-robots

1. Incorporation of the RRC ((Rosen A, & D.B. Rosen, 2003, 2006a,b,c): The RRC is an operating system that has been designed (by reverse engineering the functional characteristic of the human brain) to relate, correlate, prioritize and remember visual and auditory input data. Relating, correlating, prioritizing, and remembering visual and auditory input patterns is the essential analysis tool required to reduce the amount of programming required to achieve human-like intelligence levels to a bounded number of programming steps.

• Compared to other systems: Most other computer systems calculate, compute and solve problems related to speech processing, or sizes, distances, shapes, and colors of objects recorded in the FOV of the visual system.

2. Incorporation of the Relational Correlation Sequencer (RCS): An RRC consists of sets of RCS-modules and associated memory units called Task Selector Modules (TSMs) that operate by relating and correlating the input signals and prioritizing and remembering important correlations. The RCS is a proprietary module described by Rosen and Rosen (Rosen A, & D.B. Rosen, 2003, 2006a,b,c).

• Compared to other systems: Most other robotic systems are not made up of modules specifically designed to relate and correlate the input signals and prioritize and remember important correlations.

3. Incorporation of a Behavioral Programming Methodology for Training the humanoid Robot. Behavioral programming is achieved by training the humanoid robot to control its body, limbs, and verbal-phoneme sound generator on the basis of input data from the 6 external sensors. It is an experiential supervised programming technique analogous to the autonomous learning of a human.

The disadvantage of behavioral programming is that the RRC-robot must be a fully built, mechanically operational system before behavioral programming techniques can be initiated. The advantages of behavioral programming is that it yields human-like levels of artificial intelligence never before programmed into a computer, as follows:

a) Tactile behavioral programming yields a self location and identification level of intelligence analogous to the proprioceptive intelligence and self knowledge of a human.
b) Visual behavioral programming yields a behavioral methodology for the identification, recognition, visualization, and comprehension of the visual image in the same manner as does a human. As a matter of fact, the operational definition of human-like identification, recognition, visualization, and comprehension is derived from the behavioral programming methodology.
c) Auditory behavioral programming yields a behavioral methodology for the identification, recognition, and comprehension the “heard” sound input signals, and the capability to respond verbally (a behavioral control function), in the same manner as does a human, to the heard sounds.
d) Auditory-visual-tactile behavioral programming yields a behavioral methodology for the formation of human-like abstractions and human-like conceptualization of the input data as related to the data stored in the memory system. For example, behaviorally, a “chair” is defined as a visual object that the robot can “sit on.” Then the robot is trained to identify and recognize these objects by behaviorally “sitting on them.” Thus a “bean bag,” a bar stool, a recliner, or a folding chair would all be identified conceptually as chairs. And the robot has thereby achieved a level of abstraction for the concept of a chair. In a similar manner the robot may be trained to recognize and identify common nouns such as everyday objects like “door” (a closeable entrance or egress opening of an enclosed space), table, tree, and verbs that are descriptive of “freedom,” slavery,” democracy,” and totalitarianism.”

4. Incorporation of a central hub of intelligence: The RRC-humanoid robot is programmed to perform all tasks relative to a self-location and identification task, performed by a nodal map, known as the self nodal map/coordinate frame, and associated with one of the RCSs that make up a RRC. It is important to stress the word “all”, since no task may be performed by the system that is not related to the centralized self-nodal map/coordinate frame. The centralized self-nodal map coordinate frame is the central hub of intelligence for the system. Therefore it is easy to access data stored in the central intelligence hub.

• Compared to other systems: Most other intelligent computer systems do not relate all the programmed tasks to a single centralized coordinate frame/task. Therefore it is much more difficult to access the diverse “knowledge-data” stored in the computer system.

5. Design of a “self-knowledge” capability: A trained self-nodal map-coordinate frame gives the robot a level of intelligence that may be called robotic proprioception knowledge or “self location and identification” knowledge. The totality of the programmed “self location and identification” data, stored in a TSM-memory module, is the basis for the “self Knowledge” level of intelligence. A RRC robot with a fully programmed “self knowledge” capability “knows,” behaviorally, the location of every surface point of the robotic body, the location of flailing limbs, and by extension, the location of every coordinate frame point in the near space defined by flailing limbs.

• Compared to other systems: Most other computer systems don't have proprioceptive knowledge or a "self knowledge" capability-coordinate frame to which all other data may be related. They do not internalize the data into a self-knowledge coordinate frame; that is, they do not relate all the programmed tasks to a single centralized coordinate frame. Examples of such machines, which do not have a self-knowledge capability, are the famous Turing machine and the chess playing computers that always win when playing against a human competitor.

6. Design of an "awareness"-monitoring capability: In order to be capable of achieving a level of programmed intelligence that can be termed human-like "awareness" of the input data, the robotic system must constantly monitor the sensory data throughout the operational lifetime of the robot, and relate the monitored data to the "self knowledge" coordinate frame. When tactile sensors that form a protective covering of the robotic body, constantly monitor the environment around the robotic body for any possible tactile activation, then robotic "self knowledge" becomes another level of intelligence called "robotic self awareness" of the tactile environment around the robot. Robotic self awareness coupled with "Self knowledge" of the tactile sensory data may lead to a behavioral robotic reaction to the data that is analogous to the human-like modality of "feeling touch-pain" associated with the pressure exerted on tactile mechano-receptors (pressure transducers).

• Compared to other systems: Most other computer systems designed to perform monitoring or surveillance do not have a human-like "awareness" capability unless the monitored data is constantly related to a "self knowledge" coordinate frame.

7. ***Internalization of the data:*** In a RRC system, the sensory data obtained by any recording monitor must be "internalized" with respect to the "self knowledge" memory module. Internalization means that the data from each of the sensors must be related and correlated with the self-knowledge memory module in a manner such that the robot develops "self knowledge" of the visual data, the auditory data, the olfactory data, and the gustatory data. The "self knowledge" level of intelligence may therefore be gained for the auditory, olfactory, and gustatory sensors, in addition to the visual sensors.

• Compared to other systems: Most other computer system do not have a "self-knowledge" level of intelligence capability. And they certainly cannot extend that self knowledge capability to other sensors. That is, self knowledge may NOT be extended to the visual, auditory, olfactory, and gustatory sensors. And therefore human-like intelligence levels cannot be achieved for those sensors.

8. Quantifying the amount of programming required to reach human-like levels of AI: With the internalization process in place, achieving human-like intelligence of the sensory data is dependent on the level of training or programming performed on the RRC-controlled robot. It is a software development involving relations and correlations between signals wherein "robotic self- knowledge," "robotic awareness," "robotic comprehension," "robotic visualization," and "sensation" generation within the RRC, all refer to the level of training programming of the various modules of the RRC. The RRC-robot may be programmed behaviorally to the level of intelligence of a human that learns all the relational and correlational data taught in the educational system grades K-I through K-12. The number of relations, correlations, and priority levels stored in the TSM-memory modules of such a RRC-robot increases proportionally to the data learned in grades K-1 through K-12. And the total "knowledge" gained by the system may be quantified by the number of relations and correlations programmed and stored into the system as the robot goes from grade K-1 to grade K-12.

• Compared to other systems: The designers of most other intelligent-computer systems have never quantified the level of intelligence programmed into their system by the number of relations and correlations between the various sensory data inputs.

Part 2: Innovative features of the visual RRC-humanoid robots

1. ***A paradigm shift in methodology:*** The analytical-programming methods employed by the Visual RRC-humanoid system is a fundamental paradigm shift in the methodology generally employed by other computer vision systems. The shift in emphasis is from analytical programming methodologies involving cal-

culations of image size, distance, shape, form, and color, to an analytical methodology involving relating, correlating, prioritizing and remembering various aspects of a 3D-photometric image.

• Compared to other systems: Most other computer-vision systems perform computations and calculations of image size, distance, shape form or color in order to analyze the image.

2. Formation of a 3D-photometric image: In the visual RRC-humanoid visual system great emphasis is placed on the formation of a 3D-photometric image that is a high fidelity representation of objects/colors present in the FOV of the visual system. It is that image that is calibrated, applied to the 3D-coordinate frame defined by the "self knowledge" nodal map module, and related and correlated with other input data. In the Visual RRC- humanoid Robot, a human-like level of visualization intelligence is obtained by relating, correlating, prioritizing, remembering and acting on various aspects of the 3D-photometric image.

• Compared to other systems: The formation of a high fidelity 3D-photometric image in the interface of the visual RRC-system is a unique, innovative and advantageous way to analyze the image and gather sufficient data to reach the "visualization" level of artificial intelligence.

3. Design of an interface circuit compatible with human-like levels of AI: The visual interface circuit not only generates a 3-D photometric image, it also magnifies and displaces the image so that it is adjusted with, and completely calibrated with, the Euclidean itch scratch, self location and identification coordinate frame, the so called self knowledge coordinate frame of the system.

• Compared to other systems: The interface circuit is highly dependent on the input system of the RRC, a proprietary module of the visual RRC-humanoid robot. Therefore, no other computer vision system is capable of emulating the interface circuit of the RRC-humanoid robot.

Part 3: Innovative features of the auditory RRC-humanoid robot

The auditory RRC-humanoid robot is a visual RRC-humanoid robot equipped with a auditory monitor and verbal phoneme sound generator and programmed to reach human-like levels of declarative-verbal AI. The following innovative features have been incorporated into the system.

1. ***A paradigm shift in the analytical-programming methodology employed in speech processing systems:*** The behavioral programming methodology employed by the auditory RRC-humanoid system is a fundamental paradigm shift in the methodology generally employed by other computer speech processing systems. The shift in emphasis is from analytical programming methodologies involving calculations of acoustic signal pattern that are mapped onto phonetic structures, to an analytical methodology involving relating, correlating, prioritizing, repeating and remembering various aspects of the of the acoustic signals.
2. ***Design of an interface circuit compatible with human-like levels of AI:*** The innovativeness of the auditory RRC-system also lies in the design of an interface that facilitates a) the internalization and the human-like "self knowledge" level of intelligence of the auditory data; b) The design of a multi-dimensional p-phoneme vector space, input to the multi-dimensional auditory Nodal Map Module; and c) The incorporation of a RCS that forms a babbling Sequence Stepper Module to facilitate repetitive programming.

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