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(54) **NEURO-FEEDBACK BASED STIMULUS  
COMPRESSION DEVICE**

**Publication Classification**

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(57) **ABSTRACT**

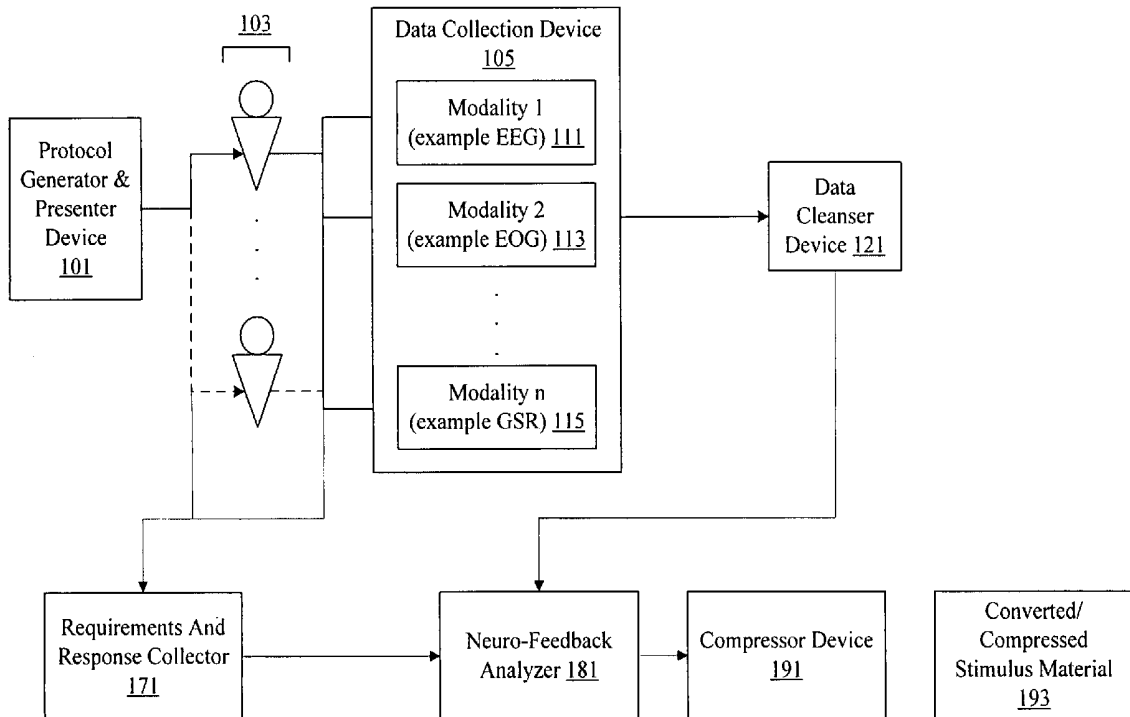
(21) Appl. No.: **12/113,870**

A stimulus compression device determines neuro-feedback significance corresponding to stimulus material and modifies the stimulus material using neuro-feedback significance measures. For example, the stimulus compression device determines portions of a media stream corresponding to low neuro-feedback significance and removes them from the media stream. Compression of stimulus material may involve removal, modification, repetition, bit rate adjustment, resolution adjustment, etc. Transitions can be smoothed or lengthened to further improve processed stimulus material.

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**Related U.S. Application Data**

(60) Provisional application No. 60/915,228, filed on May 1, 2007.



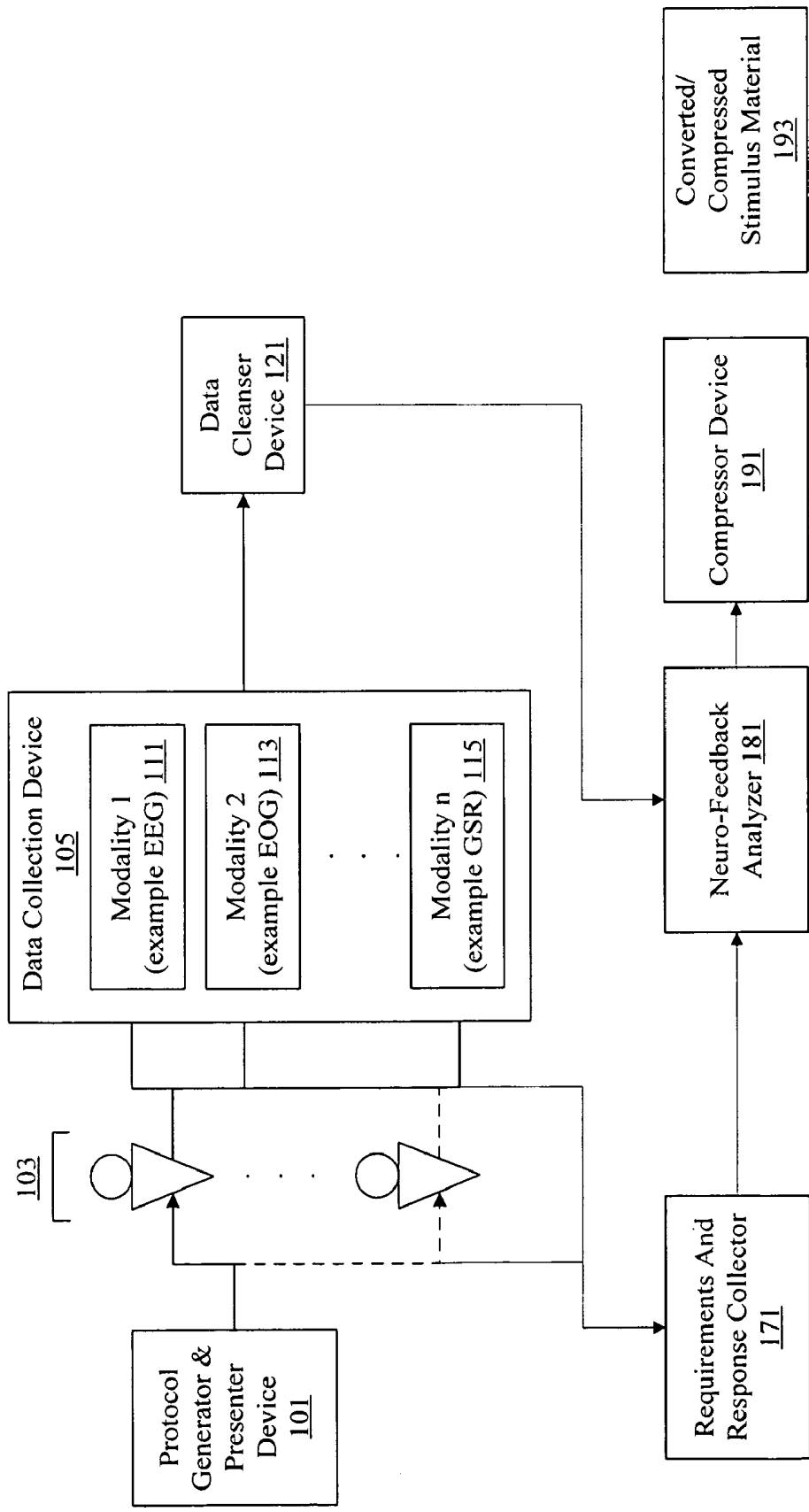


Figure 1

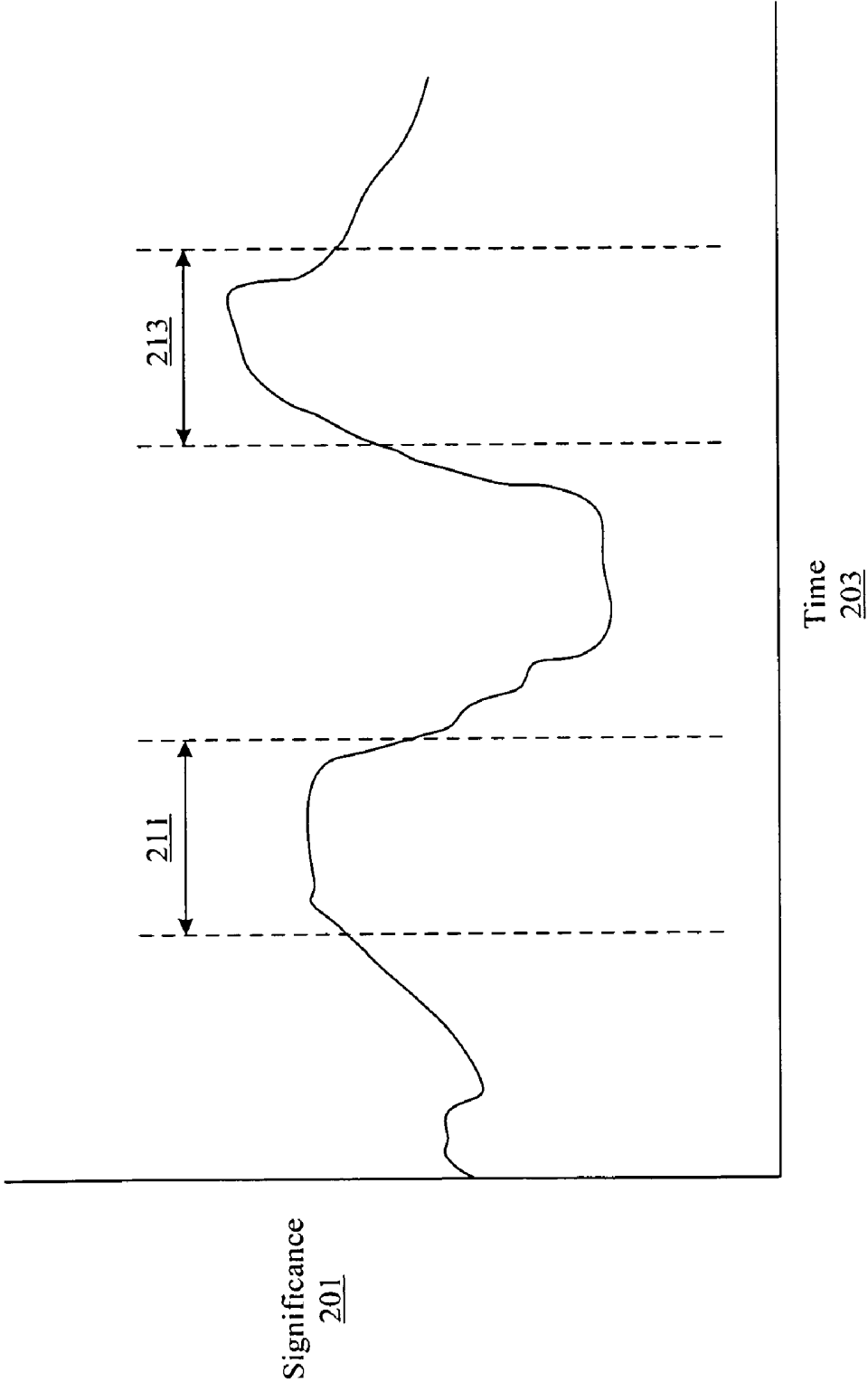


Figure 2

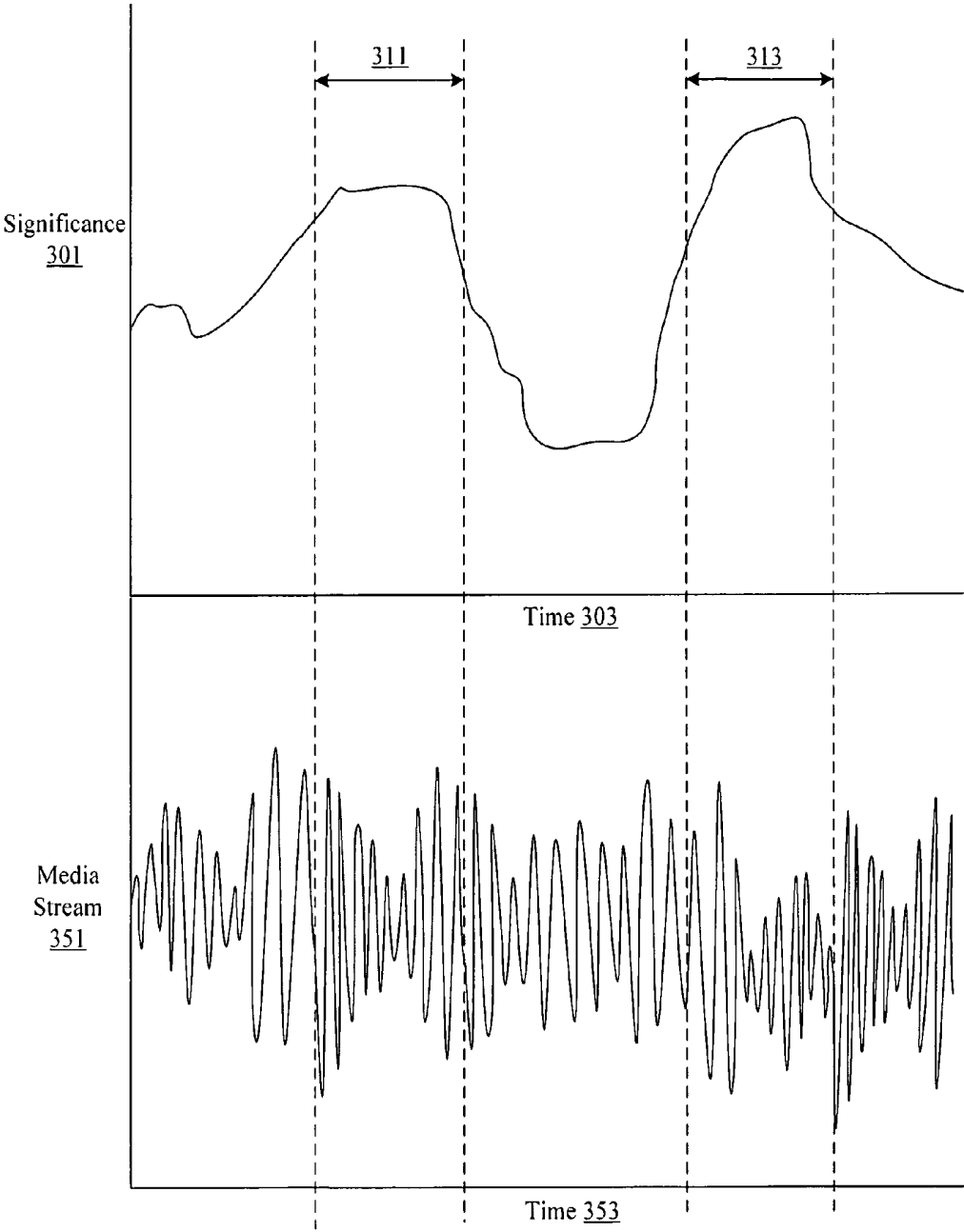


Figure 3

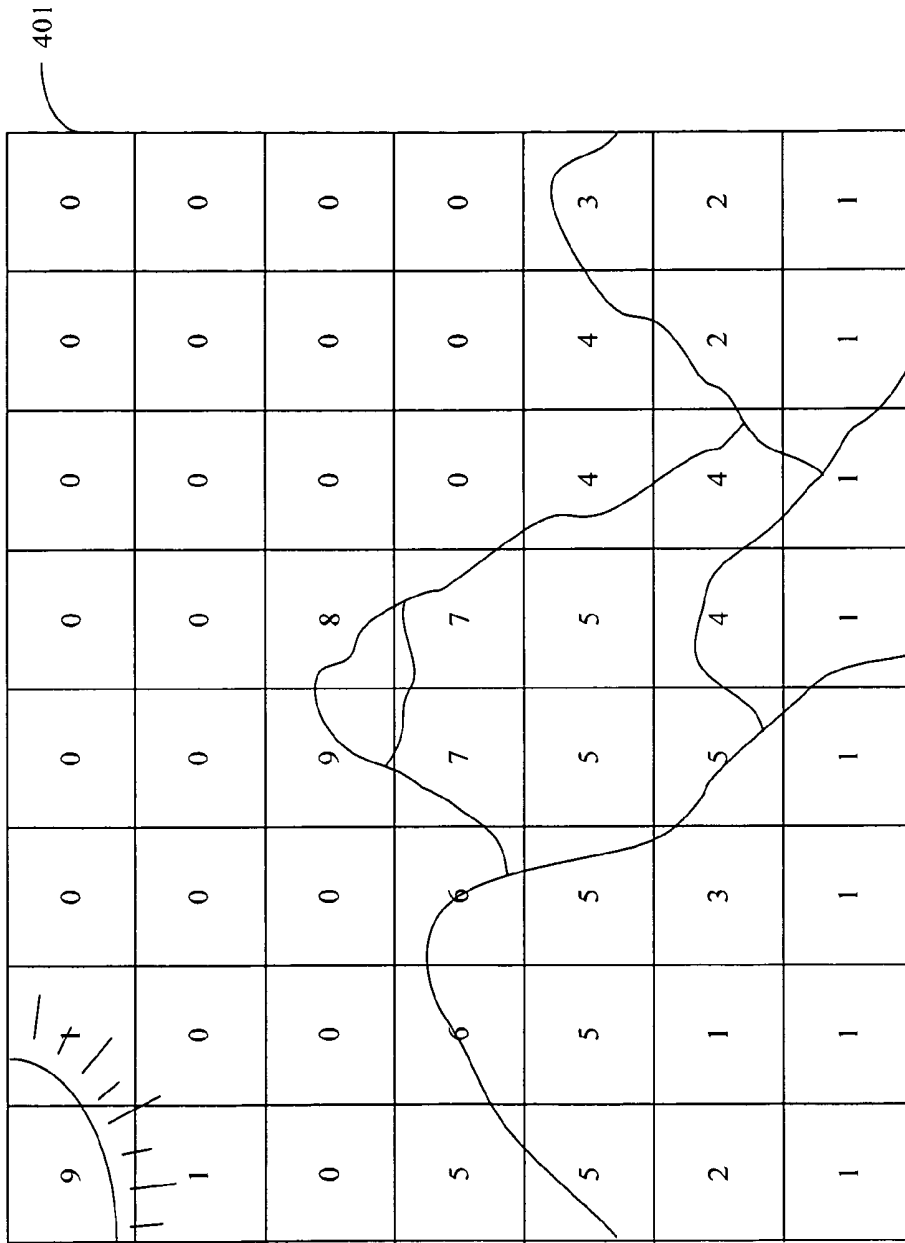


Figure 4

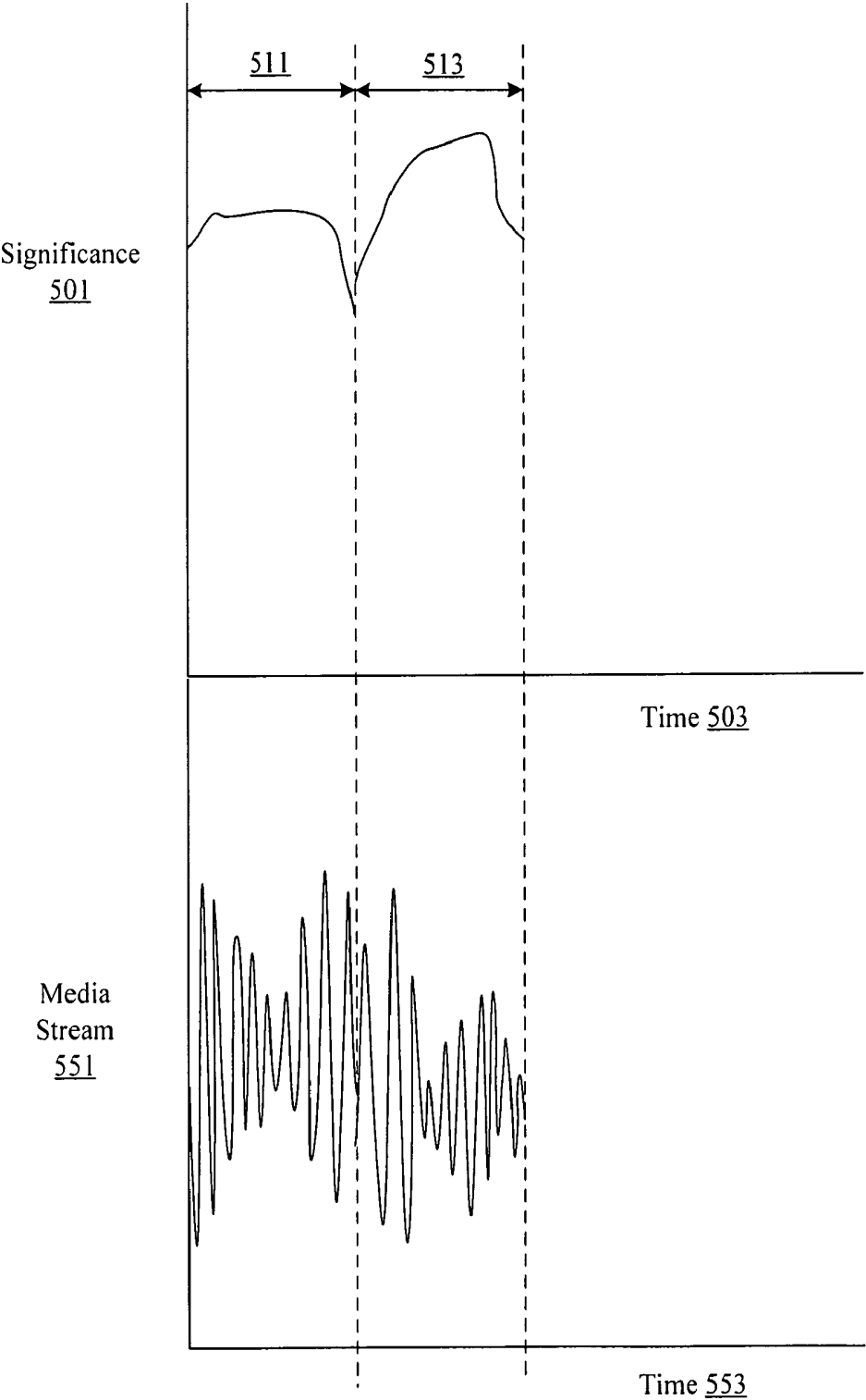


Figure 5

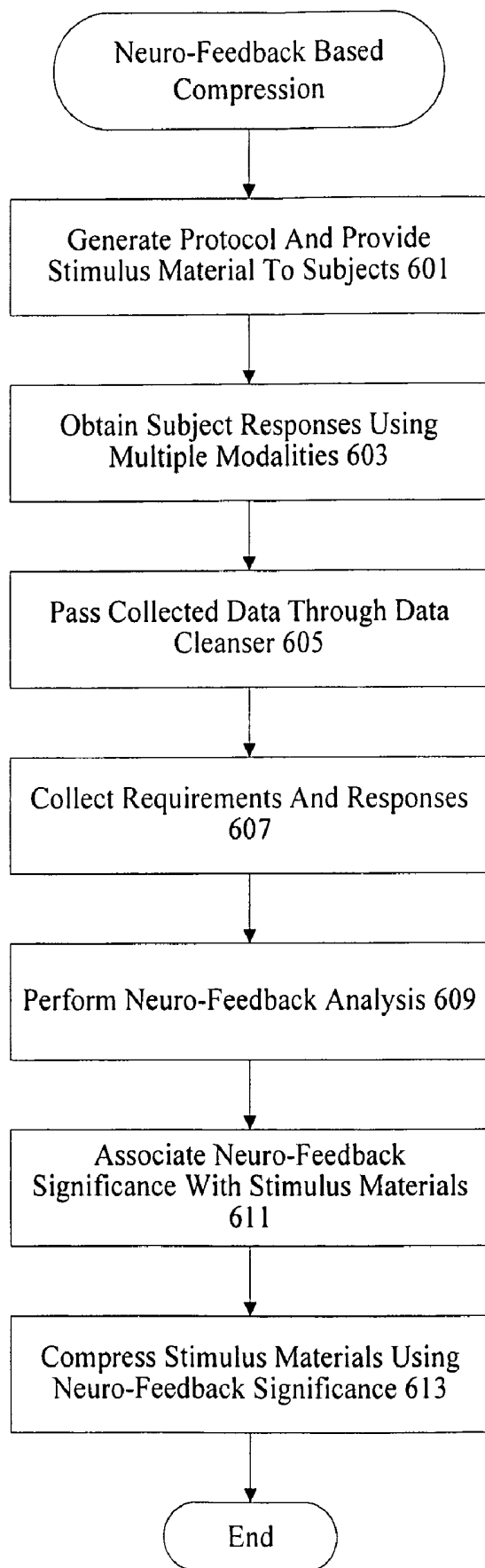


Figure 6

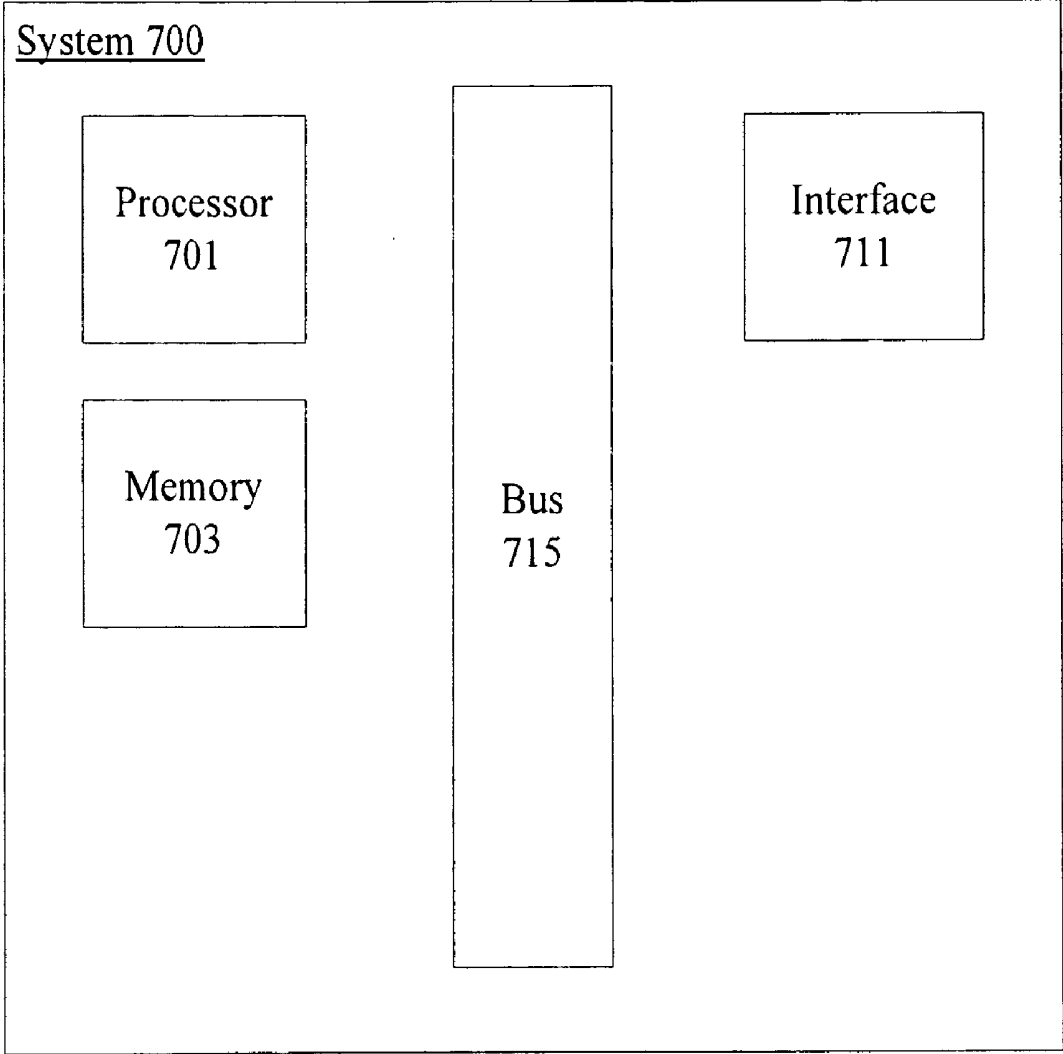


Figure 7

## NEURO-FEEDBACK BASED STIMULUS COMPRESSION DEVICE

### CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Provisional Patent Application 60/915,228 (Docket No. 2007NF4) titled Neuro-Feedback Based Stimulus Compression Device, by Anantha Pradeep, Robert T. Knight, and Ramachandran Gurumoorthy, and filed on May 1, 2007.

### TECHNICAL FIELD

[0002] The present disclosure relates to compressing materials such as marketing and entertainment materials based on neuro-feedback.

### DESCRIPTION OF RELATED ART

[0003] Conventional systems for compressing materials such as entertainment and marketing including advertising, text streams, audio clips and other stimuli often rely on survey based evaluations to measure responses to the materials. According to various embodiments, a commercial is shortened by compression by removing portions that are deemed ineffectual by survey participants. In other examples, movie scenes are deleted by manual editing based on producer or director insights. Existing mechanisms compress materials based simply on characteristics of the materials or limited survey based responses.

[0004] Consequently, it is desirable to provide improved methods and apparatus for compressing materials based on neuro-feedback.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The disclosure may best be understood by reference to the following description taken in conjunction with the accompanying drawings, which illustrate particular example embodiments.

[0006] FIG. 1 illustrates one example of a system for performing neuro-feedback based compression.

[0007] FIG. 2 illustrates one example of neuro-feedback significance data provided in relation to time.

[0008] FIG. 3 illustrates one example of neuro-feedback significance data associated with a media stream.

[0009] FIG. 4 illustrates one example of neuro-feedback significance data provided based on location.

[0010] FIG. 5 illustrates one example of a media stream compressed using neuro-feedback significance data.

[0011] FIG. 6 illustrates one example of a technique for performing neuro-feedback based compression.

[0012] FIG. 7 provides one example of a system that can be used to implement one or more mechanisms.

### DESCRIPTION OF PARTICULAR EMBODIMENTS

[0013] Reference will now be made in detail to some specific examples of the invention including the best modes contemplated by the inventors for carrying out the invention. Examples of these specific embodiments are illustrated in the accompanying drawings. While the invention is described in conjunction with these specific embodiments, it will be understood that it is not intended to limit the invention to the described embodiments. On the contrary, it is intended to

cover alternatives, modifications, and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

[0014] For example, the techniques and mechanisms of the present invention will be described in the context of time-based compression of stimuli. However, it should be noted that the techniques and mechanisms of the present invention apply to a variety of different types of compression include spatially-based compression of stimuli including entertainment and marketing such as video and audio streams, media advertising, text, printed advertisements, etc. It should be noted that various mechanisms and techniques can be applied to any type of stimuli. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. Particular example embodiments of the present invention may be implemented without some or all of these specific details. In other instances, well known process operations have not been described in detail in order not to unnecessarily obscure the present invention.

[0015] Various techniques and mechanisms of the present invention will sometimes be described in singular form for clarity. However, it should be noted that some embodiments include multiple iterations of a technique or multiple instantiations of a mechanism unless noted otherwise. For example, a system uses a processor in a variety of contexts. However, it will be appreciated that a system can use multiple processors while remaining within the scope of the present invention unless otherwise noted. Furthermore, the techniques and mechanisms of the present invention will sometimes describe a connection between two entities. It should be noted that a connection between two entities does not necessarily mean a direct, unimpeded connection, as a variety of other entities may reside between the two entities. For example, a processor may be connected to memory, but it will be appreciated that a variety of bridges and controllers may reside between the processor and memory. Consequently, a connection does not necessarily mean a direct, unimpeded connection unless otherwise noted.

### Overview

[0016] A stimulus compression device determines neuro-feedback significance corresponding to stimulus material and modifies the stimulus material using neuro-feedback significance measures. For example, the stimulus compression device determines portions of a media stream corresponding to low neuro-feedback significance and removes them from the media stream. Compression of stimulus material may involve removal, modification, repetition, bit rate adjustment, resolution adjustment, etc. Transitions can be smoothed or lengthened to further improve processed stimulus material.

### EXAMPLE EMBODIMENTS

[0017] Conventional compression mechanisms modify stimulus material such as entertainment and marketing materials using survey based instruments and subjective judgment. In some examples, an editor can shorten a media stream by using survey results and subjective judgment to compress a one minute commercial into a 15-second clip. In other examples, a clip deemed particularly effective may be repeated or emphasized in a media stream. Typically, only the material characteristics of the media stream itself are used to compress or otherwise modify the media stream.

**[0018]** However, survey results often provide only limited information on the effectiveness of stimulus material. For example, survey subjects may be unable or unwilling to express their true thoughts and feelings about a topic, or questions may be phrased with built in bias. Articulate subjects may be given more weight than non-expressive ones. The subjective judgment of an editor can similarly be biased. A variety of semantic, syntactic, metaphorical, cultural, social and interpretive biases and errors prevent accurate and repeatable evaluation.

**[0019]** Consequently, the techniques and mechanisms of the present invention use neurological and neurophysiological measurements to modify stimulus material. Some examples of central nervous system measurement mechanisms include Functional Magnetic Resonance Imaging (fMRI) and Electroencephalography (EEG). fMRI measures blood oxygenation in the brain that correlates with increased neural activity. However, current implementations of fMRI have poor temporal resolution of few seconds. EEG measures electrical activity associated with post synaptic currents occurring in the milliseconds range. Subcranial EEG can measure electrical activity with the most accuracy, as the bone and dermal layers weaken transmission of a wide range of frequencies. Nonetheless, surface EEG provides a wealth of electrophysiological information if analyzed properly.

**[0020]** Autonomic nervous system measurement mechanisms include Galvanic Skin Response (GSR), Electrocardiograms (EKG), pupillary dilation, etc. Effector measurement mechanisms include Electrooculography (EOG), eye tracking, facial emotion encoding, reaction time etc.

**[0021]** According to various embodiments, the techniques and mechanisms of the present invention intelligently blend multiple modes and manifestations of precognitive neural signatures with cognitive neural signatures and post cognitive neurophysiological manifestations to more accurately allow compression of stimulus material. In some examples, autonomic nervous system measures are themselves used to validate central nervous system measures. Effector and behavior responses are blended and combined with other measures. According to various embodiments, central nervous system, autonomic nervous system, and effector system measurements are aggregated into a neuro-feedback significance measurement that is associated with stimulus material such as a media stream and used to automatically compress the media stream.

**[0022]** In particular embodiments, portions of the stimulus material that are associated with low neuro-feedback significance are removed to leave only portions that have high neuro-feedback significance. In some examples, portions left in media stream are lengthened to provide less abrupt transitions. In other examples, other portions of stimulus material are repeated to enhance the effectiveness of stimulus material. A variety of stimulus materials such as entertainment and marketing materials, media streams, billboards, print advertisements, text streams, music, performances, sensory experiences, etc. can be compressed. It should be noted that compression can at times include other types of modification such as repetition, conversion, or expansion. In particular examples, neuro-feedback significance can be used to compress a movie into a trailer. In other examples, neuro-feedback significance can be used to identify particularly effective portions of a musical composition and aid a composer in emphasizing or repeating those portions. In still other examples, neuro-feedbacks significance can be used to iden-

tify high neuro-feedbacks significance portions of a media stream to allow transmission of those portions at a high bit rate while other portions of lower significance are transmitted at a lower bit rate to conserve bandwidth. The compression can be performed with or without user input.

**[0023]** According to various embodiments, neuro-feedback significance measurements are generated using a neuro-feedback analyzer that performs both intra-modality measurement enhancements and cross-modality measurement enhancements. According to various embodiments, brain activity is measured not just to determine the regions of activity, but to determine interactions and types of interactions between various regions. The techniques and mechanisms of the present invention recognize that interactions between neural regions support orchestrated and organized behavior. Attention, emotion, memory, and other abilities are not merely based on one part of the brain but instead rely on network interactions between brain regions.

**[0024]** The techniques and mechanisms of the present invention further recognize that different frequency bands used for multi-regional communication can be indicative of the effectiveness of stimuli. In particular embodiments, evaluations are calibrated to each subject and synchronized across subjects. In particular embodiments, templates are created for subjects to create a baseline for measuring pre and post stimulus differentials. According to various embodiments, stimulus generators are intelligent, and adaptively modify specific parameters such as exposure length and duration for each subject being analyzed. An intelligent stimulus generation mechanism intelligently adapts output for particular users and purposes. A variety of modalities can be used including EEG, GSR, EKG, pupillary dilation, EOG, eye tracking, facial emotion encoding, reaction time, etc. Individual modalities such as EEG are enhanced by intelligently recognizing neural region communication pathways. Cross modality analysis is enhanced using a synthesis and analytical blending of central nervous system, autonomic nervous system, and effector signatures. Synthesis and analysis by mechanisms such as time and phase shifting, correlating, and validating intra-modal determinations allow generation of a composite output characterizing the significance of various neuro-feedback responses.

**[0025]** FIG. 1 illustrates one example of a system for using neuro-feedback significance measures determined with central nervous system, autonomic nervous system, and effector measures. According to various embodiments, the neuro-feedback based compression system includes a protocol generator and presenter device 101. In particular embodiments, the protocol generator and presenter device 101 is merely a presenter device and merely presents stimulus material to a user. The stimuli may be a media clip, a commercial, pages of text, a brand image, a performance, a magazine advertisement, a movie, an audio presentation, particular tastes, smells, textures and/or sounds. The stimuli can involve a variety of senses and occur with or without human supervision. Continuous and discrete modes are supported. According to various embodiments, the protocol generator and presenter device 101 also has protocol generation capability to allow intelligent customization of stimuli provided to a subject.

**[0026]** According to various embodiments, the subjects are connected to data collection devices 105. The data collection devices 105 may include a variety of neurological and neurophysiological measurement mechanisms such as EEG,

EOG, GSR, EKG, pupillary dilation, eye tracking, facial emotion encoding, and reaction time devices, etc. In particular embodiments, the data collection devices **105** include EEG **111**, EOG **113**, and GSR **115**. In some instances, only a single data collection device is used. Data collection may proceed with or without human supervision.

**[0027]** The data collection device **105** collects neuro-physiological data from multiple sources. This includes a combination of devices such as central nervous system sources (EEG), autonomic nervous system sources (GSR, EKG, pupillary dilation), and effector sources (EOG, eye tracking, facial emotion encoding, reaction time). In particular embodiments, data collected is digitally sampled and stored for later analysis. In particular embodiments, the data collected could be analyzed in real-time. According to particular embodiments, the digital sampling rates are adaptively chosen based on the neurophysiological and neurological data being measured.

**[0028]** In one particular embodiment, the neuro-feedback based compression system includes EEG **111** measurements made using scalp level electrodes, EOG **113** measurements made using shielded electrodes to track eye data, GSR **115** measurements performed using a differential measurement system, a facial muscular measurement through shielded electrodes placed at specific locations on the face, and a facial affect graphic and video analyzer adaptively derived for each individual.

**[0029]** In particular embodiments, the data collection devices are clock synchronized with a protocol generator and presenter device **101**. The data collection system **105** can collect data from a single individual (1 system), or can be modified to collect synchronized data from multiple individuals (N+1 system). The N+1 system may include multiple individuals synchronously tested in isolation or in a group setting. In particular embodiments, the data collection devices also include a condition evaluation subsystem that provides auto triggers, alerts and status monitoring and visualization components that continuously monitor the status of the subject, data being collected, and the data collection instruments. The condition evaluation subsystem may also present visual alerts and automatically trigger remedial actions.

**[0030]** According to various embodiments, the neuro-feedback based compression system also includes a data cleanser device **121**. In particular embodiments, the data cleanser device **121** filters the collected data to remove noise, artifacts, and other irrelevant data using fixed and adaptive filtering, weighted averaging, advanced component extraction (like PCA, ICA), vector and component separation methods, etc. This device cleanses the data by removing both exogenous noise (where the source is outside the physiology of the subject) and endogenous artifacts (where the source could be neurophysiological like muscle movement, eye blinks, etc.).

**[0031]** The artifact removal subsystem includes mechanisms to selectively isolate and review the response data and identify epochs with time domain and/or frequency domain attributes that correspond to artifacts such as line frequency, eye blinks, and muscle movements. The artifact removal subsystem then cleanses the artifacts by either omitting these epochs, or by replacing these epoch data with an estimate based on the other clean data (for example, an EEG nearest neighbor weighted averaging approach).

**[0032]** According to various embodiments, the data cleanser device **121** is implemented using hardware, firm-

ware, and/or software. It should be noted that although a data cleanser device **121** is shown located after a data collection device **105** and before neuro-feedback analyzer **181**, the data cleanser device **121** like other components may have a location and functionality that varies based on system implementation. For example, some systems may not use any automated data cleanser device whatsoever. In other systems, data cleanser devices may be integrated into individual data collection devices.

**[0033]** A requirements and response collector **171** customizes and extracts characteristics of the stimulus material provided for compression. According to various embodiments, the requirements and response collector **171** obtains the purpose of the material, parameters associated with the material, and presentations of the stimulus material provided for compression. It also includes a mechanism for optionally collecting survey responses from the subjects. In some examples, the requirements and response collector **171** may only collect parameters and representations of the presentation.

**[0034]** According to various embodiments, the purpose of the stimulus material is obtained to determine objectives for the compressed material. Examples of objectives may include excitement about a product or service or memory retention of a brand name. According to various embodiments, the parameters associated with the material include channel, media type, time span, audience, and target demographic. The purpose and parameters may affect how neuro-feedback significance is determined. According to various embodiments, the neuro-feedback based compression system also collects presentation or view specific attributes such as audio, video, imagery and messages for enhancement and modification. In some examples, merely representations of the presentation are obtained.

**[0035]** The requirements and response collector **171** can obtain data with or without human intervention and can be implemented using hardware, firmware, and/or software. The data cleanser device **121** and the requirements and response collector **171** pass data to the neuro-feedback analyzer **181**. The neuro-feedback analyzer **181** uses a variety of mechanisms to analyze underlying data in the system to determine neuro-feedback significance measures for the stimulus material. According to various embodiments, the neuro-feedback analyzer customizes and extracts the independent neurological and neuro-physiological parameters for each individual in each modality, and blends the estimates within a modality as well as across modalities to elicit an enhanced response to the presented stimulus material. In particular embodiments, the neuro-feedback analyzer **181** aggregates the response measures across subjects in a dataset.

**[0036]** According to various embodiments, neurological and neuro-physiological signatures are measured using time domain analyses and frequency domain analyses. Such analyses use parameters that are common across individuals as well as parameters that are unique to each individual. The analyses could also include statistical parameter extraction and fuzzy logic based attribute estimation from both the time and frequency components of the synthesized response.

**[0037]** In some examples, statistical parameters used in a blended neuro-feedback significance estimate include evaluations of skew, peaks, first and second moments, population distribution, as well as fuzzy estimates of attention, emotional engagement and memory retention responses. The analyses

could also include assessing neuro-feedback significance measures for identifying segments of the stimulus material for compression.

**[0038]** According to various embodiments, the neuro-feedback analyzer **181** may include an intra-modality response synthesizer and a cross-modality response synthesizer. In particular embodiments, the intra-modality response synthesizer is configured to customize and extract the independent neurological and neurophysiological parameters for each individual in each modality and blend the estimates within a modality analytically to elicit an enhanced response to the presented stimuli. In particular embodiments, the intra-modality response synthesizer also aggregates data from different subjects in a dataset.

**[0039]** According to various embodiments, the cross-modality response synthesizer or fusion device blends different intra-modality responses, including raw signals and signals output. The combination of signals enhances the measures of effectiveness within a modality. The cross-modality response fusion device can also aggregate data from different subjects in a dataset.

**[0040]** According to various embodiments, the neuro-feedback analyzer **181** also includes a composite enhanced effectiveness estimator (CEEE) that combines the enhanced responses and estimates from each modality to provide a blended estimate of the neuro-feedback significance.

**[0041]** According to various embodiments, the neuro-feedback analyzer **181** provides neuro-feedback significance measurements to a compressor device **191**. Compressor device **191** a tool that uses the requirements and the neuro-feedback significance measurements to perform the actual compression of the stimulus material. It should be noted that compression can be performed along a variety of dimensions. In particular embodiments, compression entails removing time segments of a media stream. In other examples, compression entails removing areas of printed materials. In still other examples, compression involves removing both areas as well as time sequences. It should be noted that compression can also include expansion, repetition, conversion, bit rate and resolution modification, etc. The compressor device **191** can also use conventional video and audio encoding and decoding mechanisms to further enhance a media stream.

**[0042]** The compressor device **191** could also use the elicited neurological and physiological significance measures for identifying attributes and segments of the advertisement and other audio/visual material that need to be retained in conversion, and attributes and segments of the material that could be modified, added, and/or deleted. The compressor device **191**, like many components in a neuro-feedback based compression system can be implemented using software, firmware, and/or hardware and may be used with or without user input.

**[0043]** FIG. 2 illustrates one example of neuro-feedback significance data **201** provided in relation to time **203**. According to various embodiments, neuro-feedback significance data **201** is generated using a neuro-feedback analyzer. In particular embodiments, the neuro-feedback analyzer processes underlying data in the system to determine neuro-feedback significance measures for the stimulus material. According to various embodiments, the neuro-feedback analyzer customizes and extracts the independent neurological and neuro-physiological parameters for each individual in each modality, and blends the estimates within a modality as well as across modalities to elicit an enhanced response to the

presented stimulus material. In particular embodiments, the neuro-feedback analyzer aggregates the response measures across subjects in a dataset.

**[0044]** According to various embodiments, the neuro-feedback significance data **201** is processed to identify portions **211** and **213** having high neuro-feedback significance. In some examples, threshold values may be used to determine high neuro-feedback significance portions. In other examples, a particular number of portions having above average significance in relation to other portions are identified. A variety of mechanisms can be used to identify high neuro-feedback significance portions.

**[0045]** FIG. 3 illustrates one example of neuro-feedback significance data association with a media stream. According to various embodiments, a neuro-feedback significance graph is generated using combined, shifted, and aligned neurological and neurophysiological measures. In some examples, other data such as survey data can also be combined into a significance graph. The significance data **301** is graphed with respect to time **303** and portions **311** and **313** have high neuro-feedback significance are identified. It should be noted that other portions such as widely varying significance or low significance may also be identified in some examples. Stimulus material such as media stream **351** is associated with the neuro-feedback significance graph to identify portions **311** and **313** in the media stream graphed with respect to time **353**.

**[0046]** These portions may be emphasized when a movie is compressed into a movie trailer, a media stream is compressed for transmission on limited bandwidth networks, or a laser light show is evaluated for editing. In particular embodiments, if portions identified are too small, the portions are lengthened slightly to include material that may not have as high a neuro-feedback significance rating. Transitions in the media stream **351** may be smoothed to improve user viewing experience.

**[0047]** FIG. 4 illustrates one example of neuro-feedback significance data associated with an image. According to various embodiments, EOG and eye tracking benefits from grouping objects of interest into temporally and spatially defined entities using micro and macro saccade patterns. Gaze, dwell, return of eye movements to primarily center around the defined entities of interest and inhibition of return to novel regions of the material being evaluated are measured to determine the degree of engagement and attention evoked by the stimulus material **401**. In particular embodiments, portions of the image are associated with neuro-feedback significance values to identify portions that may be compressed. In some examples, areas having low neuro-feedback significance are identified as portions that may be overwritten with text. In other instances, areas having low neuro-feedback significance may be removed to automatically or semi-automatically generate a small print advertisement from a billboard.

**[0048]** FIG. 5 illustrates one example of stimulus material compression. According to various embodiments, portions of stimulus material corresponding to high neuro-feedback significance **511** and **513** are used to generate compressed stimulus material. In one example, a media stream **551** is associated with neuro-feedback significance **501** mapped with respect to time **553** and **503**. The media stream **551** is generated to include portions that have high neuro-feedback significance.

**[0049]** A variety of mechanisms can be used to develop neuro-feedback significance measures. In particular embodiments, EEG response data is synthesized to provide an

enhanced assessment of neuro-feedback significance. According to various embodiments, EEG measures electrical activity resulting from thousands of simultaneous neural processes associated with different portions of the brain. EEG data can be classified in various bands. According to various embodiments, brainwave frequencies include delta, theta, alpha, beta, and gamma frequency ranges. Delta waves are classified as those less than 4 Hz and are prominent during deep sleep. Theta waves have frequencies between 3.5 to 7.5 Hz and are associated with memories, attention, emotions, and sensations. Theta waves are typically prominent during states of internal focus.

**[0050]** Alpha frequencies reside between 7.5 and 13 Hz and typically peak around 10 Hz. Alpha waves are prominent during states of relaxation. Beta waves have a frequency range between 14 and 30 Hz. Beta waves are prominent during states of motor control, long range synchronization between brain areas, analytical problem solving, judgment, and decision making. Gamma waves occur between 30 and 60 Hz and are involved in binding of different populations of neurons together into a network for the purpose of carrying out a certain cognitive or motor function, as well as in attention and memory. Because the skull and dermal layers attenuate waves in this frequency range, brain waves above 75-80 Hz are difficult to detect and are often not used for stimuli response assessment.

**[0051]** However, the techniques and mechanisms of the present invention recognize that analyzing high gamma band (kappa-band: Above 60 Hz) measurements, in addition to theta, alpha, beta, and low gamma band measurements, enhances neurological attention, emotional engagement and retention component estimates. In particular embodiments, EEG measurements including difficult to detect high gamma or kappa band measurements are obtained, enhanced, and evaluated. Subject and task specific signature sub-bands in the theta, alpha, beta, gamma and kappa bands are identified to provide enhanced response estimates. According to various embodiments, high gamma waves (kappa-band) above 80 Hz (typically detectable with sub-cranial EEG and/or magnetoencephalography) can be used in inverse model-based enhancement of the frequency responses to the stimuli.

**[0052]** Various embodiments of the present invention recognize that particular sub-bands within each frequency range have particular prominence during certain activities. A subset of the frequencies in a particular band is referred to herein as a sub-band. For example, a sub-band may include the 40-45 Hz range within the gamma band. In particular embodiments, multiple sub-bands within the different bands are selected while remaining frequencies are band pass filtered. In particular embodiments, multiple sub-band responses may be enhanced, while the remaining frequency responses may be attenuated.

**[0053]** An information theory based band-weighting model is used for adaptive extraction of selective dataset specific, subject specific, task specific bands to enhance the neuro-feedback significance measure. Adaptive extraction may be performed using fuzzy scaling. Stimuli can be presented and enhanced measurements determined multiple times to determine the variation or habituation profiles across multiple presentations. Determining the variation and/or habituation profiles provides an enhanced assessment of the primary responses as well as the longevity (wear-out) of the marketing and entertainment stimuli. The synchronous response of multiple individuals to stimuli presented in concert is measured to

determine an enhanced across subject synchrony measure of effectiveness. According to various embodiments, the synchronous response may be determined for multiple subjects residing in separate locations or for multiple subjects residing in the same location.

**[0054]** Although a variety of synthesis mechanisms are described, it should be recognized that any number of mechanisms can be applied—in sequence or in parallel with or without interaction between the mechanisms. In some examples, processes 321 and 323 can be applied to any modality.

**[0055]** Although intra-modality synthesis mechanisms provide enhanced significance data, additional cross-modality synthesis mechanisms can also be applied. A variety of mechanisms such as EEG, Eye Tracking, GSR, EOG, and facial emotion encoding are connected to a cross-modality synthesis mechanism. Other mechanisms as well as variations and enhancements on existing mechanisms may also be included. According to various embodiments, data from a specific modality can be enhanced using data from one or more other modalities. In particular embodiments, EEG typically makes frequency measurements in different bands like alpha, beta and gamma to provide estimates of significance. However, the techniques of the present invention recognize that significance measures can be enhanced further using information from other modalities.

**[0056]** For example, facial emotion encoding measures can be used to enhance the valence of the EEG emotional engagement measure. EOG and eye tracking saccadic measures of object entities can be used to enhance the EEG estimates of significance including but not limited to attention, emotional engagement, and memory retention. According to various embodiments, a cross-modality synthesis mechanism performs time and phase shifting of data to allow data from different modalities to align. In some examples, it is recognized that an EEG response will often occur hundreds of milliseconds before a facial emotion measurement changes. Correlations can be drawn and time and phase shifts made on an individual as well as a group basis. In other examples, saccadic eye movements may be determined as occurring before and after particular EEG responses. According to various embodiments, time corrected GSR measures are used to scale and enhance the EEG estimates of significance including attention, emotional engagement and memory retention measures.

**[0057]** Evidence of the occurrence or non-occurrence of specific time domain difference event-related potential components (like the DERP) in specific regions correlates with subject responsiveness to specific stimulus. According to various embodiments, ERP measures are enhanced using EEG time-frequency measures (ERPSP) in response to the presentation of the marketing and entertainment stimuli. Specific portions are extracted and isolated to identify ERP, DERP and ERPSP analyses to perform. In particular embodiments, an EEG frequency estimation of attention, emotion and memory retention (ERPSP) is used as a co-factor in enhancing the ERP, DERP and time-domain response analysis.

**[0058]** EOG measures saccades to determine the presence of attention to specific objects of stimulus. Eye tracking measures the subject's gaze path, location and dwell on specific objects of stimulus. According to various embodiments, EOG and eye tracking is enhanced by measuring the presence of lambda waves (a neurophysiological index of saccade effec-

tiveness) in the ongoing EEG in the occipital and extra striate regions, triggered by the slope of saccade-onset to estimate the significance of the EOG and eye tracking measures. In particular embodiments, specific EEG signatures of activity such as slow potential shifts and measures of coherence in time-frequency responses at the Frontal Eye Field (FEF) regions that preceded saccade-onset are measured to enhance the effectiveness of the saccadic activity data.

**[0059]** GSR typically measures the change in general arousal in response to stimulus presented. According to various embodiments, GSR is enhanced by correlating EEG/ERP responses and the GSR measurement to get an enhanced estimate of subject engagement. The GSR latency baselines are used in constructing a time-corrected GSR response to the stimulus. The time-corrected GSR response is co-factored with the EEG measures to enhance GSR significance measures.

**[0060]** According to various embodiments, facial emotion encoding uses templates generated by measuring facial muscle positions and movements of individuals expressing various emotions prior to the testing session. These individual specific facial emotion encoding templates are matched with the individual responses to identify subject emotional response. In particular embodiments, these facial emotion encoding measurements are enhanced by evaluating inter-hemispherical asymmetries in EEG responses in specific frequency bands and measuring frequency band interactions. The techniques of the present invention recognize that not only are particular frequency bands significant in EEG responses, but particular frequency bands used for communication between particular areas of the brain are significant. Consequently, these EEG responses enhance the EMG, graphic and video based facial emotion identification.

**[0061]** FIG. 6 is a flow process diagram showing a technique for compressing stimulus material using neuro-feedback significance information. At **601**, a protocol is generated and stimulus material is provided to one or more subjects. According to various embodiments, stimulus includes streaming video, media clips, printed materials, presentations, performances, games, etc. The protocol determines the parameters surrounding the presentation of stimulus, such as the number of times shown, the duration of the exposure, sequence of exposure, segments of the stimulus to be shown, etc. Subjects may be isolated during exposure or may be presented materials in a group environment with or without supervision. At **603**, subject responses are collected using a variety of modalities, such as EEG, ERP, EOG, GSR, etc. In some examples, verbal and written responses can also be collected and correlated with neurological and neurophysiological responses. At **605**, data is passed through a data cleanser to remove noise and artifacts that may make data more difficult to interpret. According to various embodiments, the data cleanser removes EEG electrical activity associated with blinking and other endogenous/exogenous artifacts.

**[0062]** At **607**, requirements and responses are collected. According to various embodiments, requirements for the stimulus material are collected to determine the purpose of the materials. Parameters and views for the material for compression is also collected.

**[0063]** At **609**, neuro-feedback analysis is performed. Neuro-feedback analysis may include intra-modality response synthesis and cross-modality response synthesis to enhance significance measures. It should be noted that in

some particular instances, one type of synthesis may be performed without performing the other type of synthesis. For example, cross-modality response synthesis may be performed with or without intra-modality synthesis. At **611**, neuro-feedback significance is associated with stimulus materials. At **613**, stimulus materials are compressed using neuro-feedback significance information. Compression may include general modification.

**[0064]** According to various embodiments, various mechanisms such as the data collection mechanisms, the intra-modality synthesis mechanisms, cross-modality synthesis mechanisms, etc. are implemented on multiple devices. However, it is also possible that the various mechanisms be implemented in hardware, firmware, and/or software in a single system. FIG. 7 provides one example of a system that can be used to implement one or more mechanisms. For example, the system shown in FIG. 7 may be used to implement a data cleanser device or a cross-modality responses synthesis device.

**[0065]** According to particular example embodiments, a system **700** suitable for implementing particular embodiments of the present invention includes a processor **701**, a memory **703**, an interface **711**, and a bus **715** (e.g., a PCI bus). When acting under the control of appropriate software or firmware, the processor **701** is responsible for such tasks such as pattern generation. Various specially configured devices can also be used in place of a processor **701** or in addition to processor **701**. The complete implementation can also be done in custom hardware. The interface **711** is typically configured to send and receive data packets or data segments over a network. Particular examples of interfaces the device supports include host bus adapter (HBA) interfaces, Ethernet interfaces, frame relay interfaces, cable interfaces, DSL interfaces, token ring interfaces, and the like.

**[0066]** In addition, various very high-speed interfaces may be provided such as fast Ethernet interfaces, Gigabit Ethernet interfaces, ATM interfaces, HSSI interfaces, POS interfaces, FDDI interfaces and the like. Generally, these interfaces may include ports appropriate for communication with the appropriate media. In some cases, they may also include an independent processor and, in some instances, volatile RAM. The independent processors may control such communications intensive tasks as data synthesis.

**[0067]** According to particular example embodiments, the system **700** uses memory **703** to store data, algorithms and program instructions. The program instructions may control the operation of an operating system and/or one or more applications, for example. The memory or memories may also be configured to store received data and process received data.

**[0068]** Because such information and program instructions may be employed to implement the systems/methods described herein, the present invention relates to tangible, machine readable media that include program instructions, state information, etc. for performing various operations described herein. Examples of machine-readable media include, but are not limited to, magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD-ROM disks and DVDs; magneto-optical media such as optical disks; and hardware devices that are specially configured to store and perform program instructions, such as read-only memory devices (ROM) and random access memory (RAM). Examples of program instructions include both

machine code, such as produced by a compiler, and files containing higher level code that may be executed by the computer using an interpreter.

[0069] Although the foregoing invention has been described in some detail for purposes of clarity of understanding, it will be apparent that certain changes and modifications may be practiced within the scope of the appended claims. Therefore, the present embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalents of the appended claims.

What is claimed is:

1. A system, comprising:
  - a data collection mechanism including a plurality of modalities operable to obtain response data from a subject exposed to stimulus material, the response data including central nervous system, autonomic nervous system, and effector data;
  - a compressor device operable to associate neuro-feedback significance with the stimulus material and compress portions of the stimulus material based at least in part on neuro-feedback significance.
2. The system of claim 1, wherein neuro-feedback significance is determined using neurological and neurophysiological measurements including attention, emotion, and memory retention.
3. The system of claim 1, wherein neuro-feedback significance is determined using combinations of neurological and neurophysiological measurements including attention, emotion, and memory retention.
4. The system of claim 1, wherein response data includes neurological and neurophysiological response data.
5. The system of claim 1, wherein the stimulus material is an advertisement stream.
6. The system of claim 5, wherein portions of the advertisement stream corresponding to low neuro-feedback significance are automatically removed to shorten the advertisement stream.
7. The system of claim 1, wherein the stimulus material is a motion picture.
8. The system of claim 7, wherein portions of the motion picture corresponding to low neuro-feedback significance are automatically removed to generate a movie trailer.
9. The system of claim 1, wherein the stimulus material is a print advertisement.
10. The system of claim 9, wherein portions of the print advertisement are automatically removed to reduce the area consumed by the print advertisement.
11. The system of claim 1, wherein the stimulus material is marketing or entertainment material
12. The system of claim 9, wherein portions of the marketing or entertainment material are automatically modified to highlight effective segments

13. The system of claim 1, wherein neuro-feedback significance is determined further using survey responses.

14. The system of claim 1, wherein compressing portions of the stimulus material comprises removing portions of the stimulus material that correspond to low neuro-feedback significance.

15. The system of claim 1, wherein compressing portions of the stimulus material comprises bit rate and/or resolution adjustment.

16. The system of claim 1, wherein compressing portions of the stimulus material comprises modification, expansion, and repetition.

17. The system of claim 1, further comprising:

a cross-modality response synthesizer operable to analyze response data from the plurality of modalities, wherein response data from a first modality is aligned and combined with response data from a second modality to determine neuro-feedback significance.

18. The system of claim 15, wherein aligning response data from a first data with response data from a second modality comprises time and phase shifting, wherein the plurality of modalities include Electroencephalography (EEG), Electrooculography (EOG), and Galvanic Skin Response (GSR).

19. A method, comprising:

obtaining response data from a subject exposed to stimulus material, the response data obtained using a plurality of modalities, the response data including central nervous system, autonomic nervous system, and effector data; associating neuro-feedback significance with the stimulus material; and

compressing portions of the stimulus material based at least in part on neuro-feedback significance.

20. The system of claim 19, wherein neuro-feedback significance is determined using neurological and neurophysiological measurements including attention, emotion, and memory retention.

21. The system of claim 19, wherein neuro-feedback significance is determined using combinations of neurological and neurophysiological measurements including attention, emotion, and memory retention.

22. The system of claim 19, wherein response data includes neurological and neurophysiological response data.

23. A system, comprising:

means for obtaining response data from a subject exposed to stimulus material, the response data obtained using a plurality of modalities, the response data including central nervous system, autonomic nervous system, and effector data;

means for associating neuro-feedback significance with the stimulus material; and

means for compressing portions of the stimulus material based at least in part on neuro-feedback significance.

\* \* \* \* \*

专利名称(译)	基于神经反馈的刺激压缩装置		
公开(公告)号	<a href="#">US20090024475A1</a>	公开(公告)日	2009-01-22
申请号	US12/113870	申请日	2008-05-01
申请(专利权)人(译)	NeuroFocus的INC.		
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IPC分类号	G06Q30/00 A61B5/00 A61B5/0476 A61B5/0496		
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其他公开文献	US9886981		
外部链接	<a href="#">Espacenet</a> <a href="#">USPTO</a>		

摘要(译)

刺激压缩装置确定对应于刺激材料的神经反馈重要性，并使用神经反馈显著性测量来修改刺激材料。例如，刺激压缩设备确定对应于低神经反馈重要性的媒体流的部分并将其从媒体流中移除。刺激材料的压缩可以涉及移除，修改，重复，比特率调整，分辨率调整等。可以平滑或延长过渡以进一步改善处理的刺激材料。

