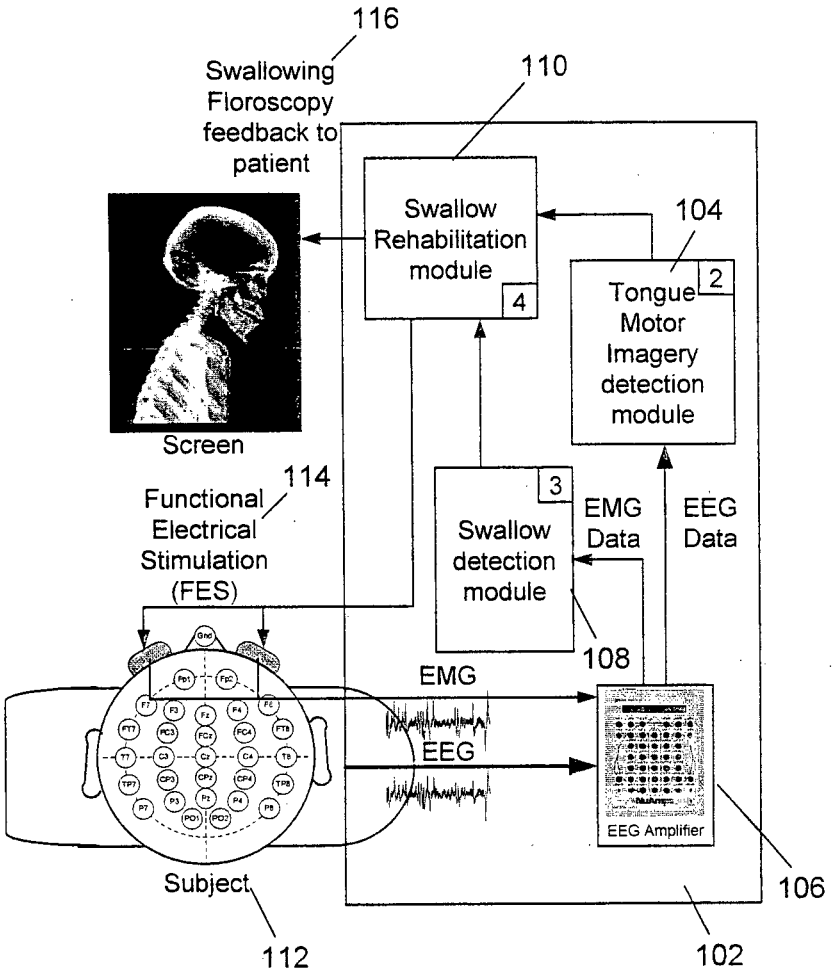

116
Swallowing Floroscopy feedback to patient
110
Swallow Rehabilitation module
4
104
Tongue Motor Imagery detection module
2
Screen
114
Functional Electrical Stimulation (FES)
3
Swallow detection module
EMG Data
EEG Data
108
EMG
EEG
EEG Amplifier
106
Subject
112
102

Figure 1

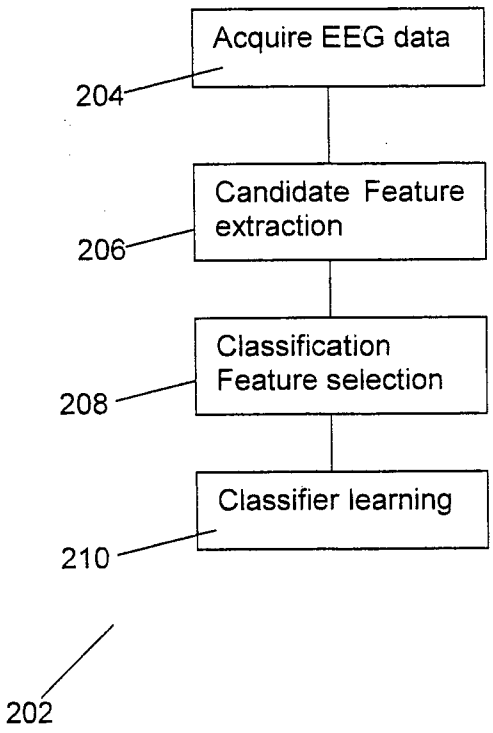

Acquire EEG data
204
Candidate Feature extraction
206
Classification Feature selection
208
Classifier learning
210
202

Figure 2

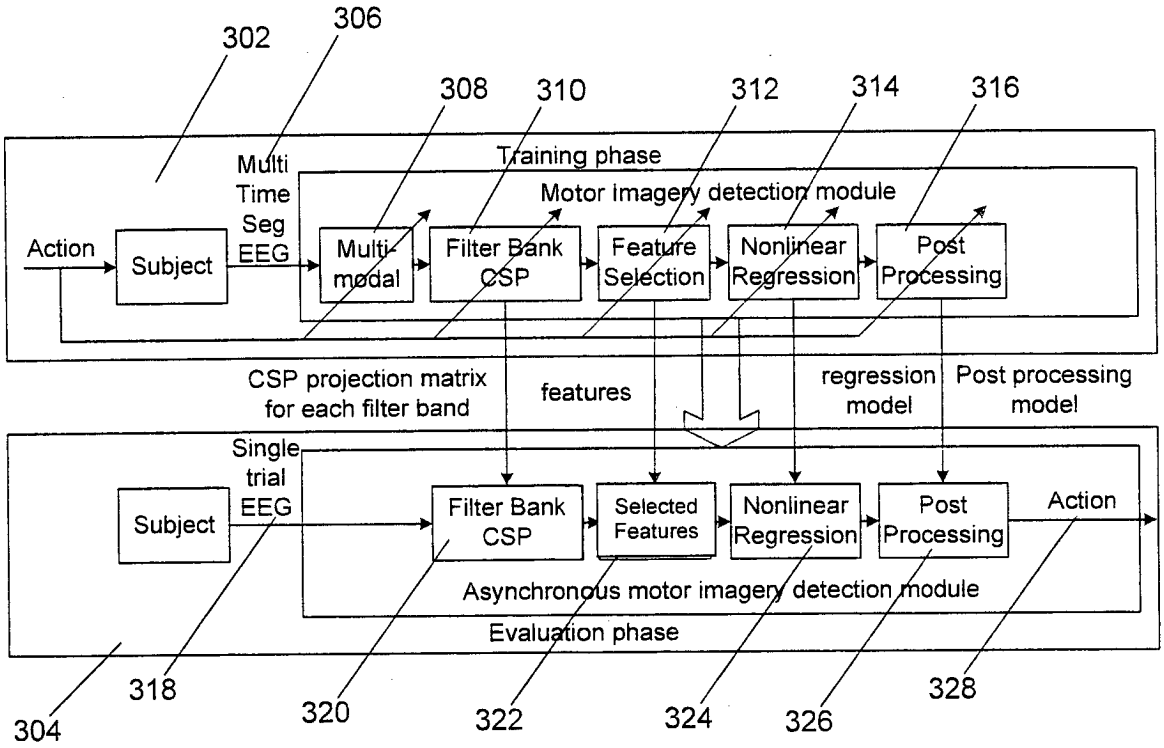

302
306
308
310
312
314
316
Training phase
Motor Imagery detection module
Multi Time Seg EEG
Action
Subject
Multi-modal
Filter Bank CSP
Feature Selection
Nonlinear Regression
Post Processing
CSP projection matrix for each filter band
features
regression model
Post processing model
Single trial EEG
Subject
Filter Bank CSP
Selected Features
Nonlinear Regression
Post Processing
Action
Asynchronous motor imagery detection module
Evaluation phase
304
318
320
322
324
326
328

Figure 3

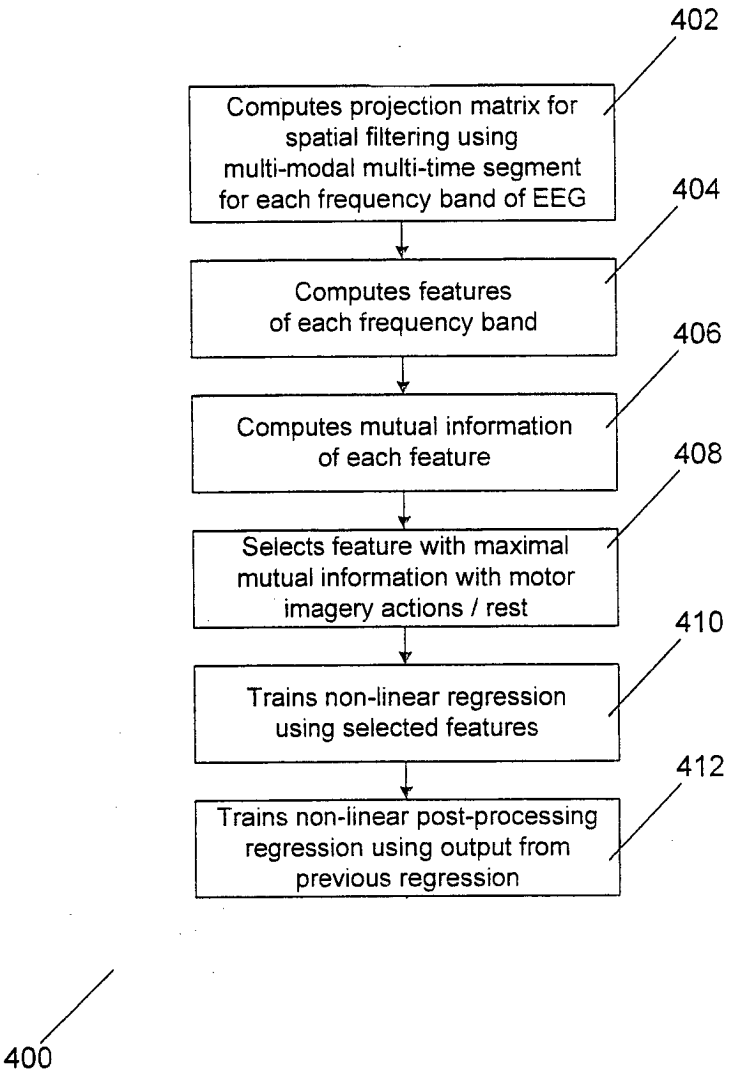

402
Computes projection matrix for spatial filtering using multi-modal multi-time segment for each frequency band of EEG
404
Computes features of each frequency band
406
Computes mutual information of each feature
408
Selects feature with maximal mutual information with motor imagery actions / rest
410
Trains non-linear regression using selected features
412
Trains non-linear post-processing regression using output from previous regression
400

Figure 4

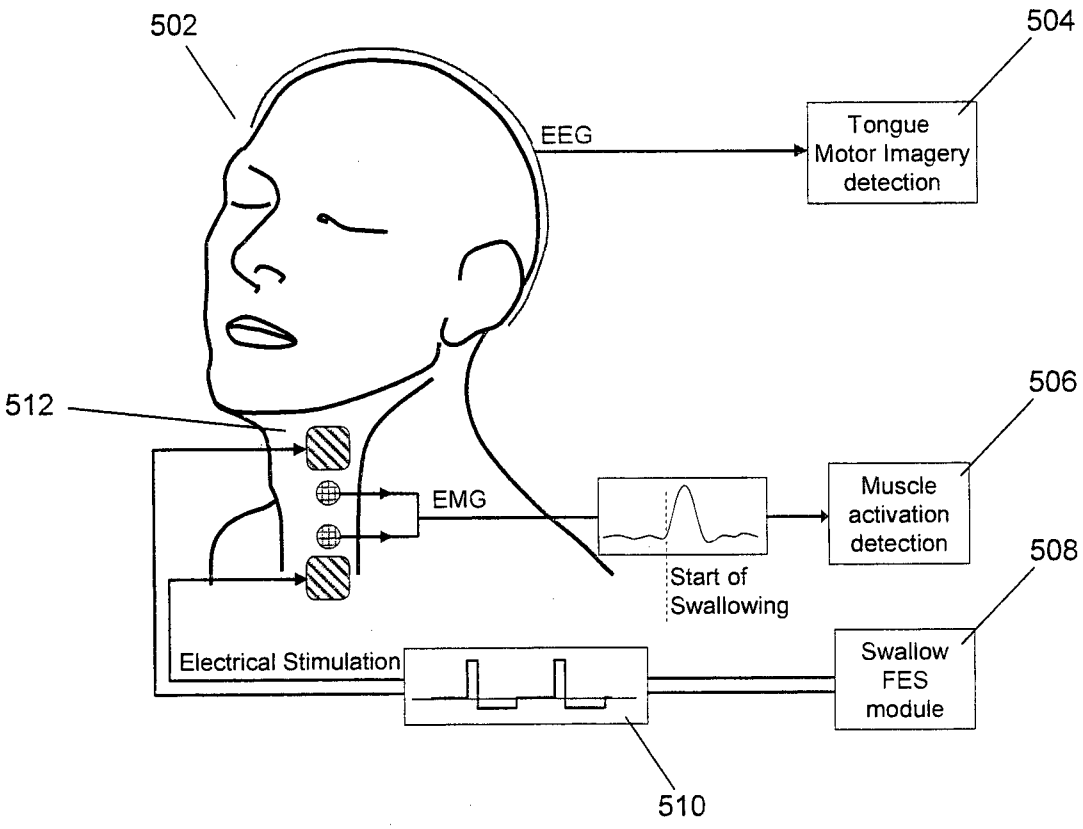

502
504
EEG
Tongue
Motor Imagery
detection
512
506
EMG
Muscle
activation
detection
Start of
Swallowing
508
Electrical Stimulation
Swallow
FES
module
510

Figure 5

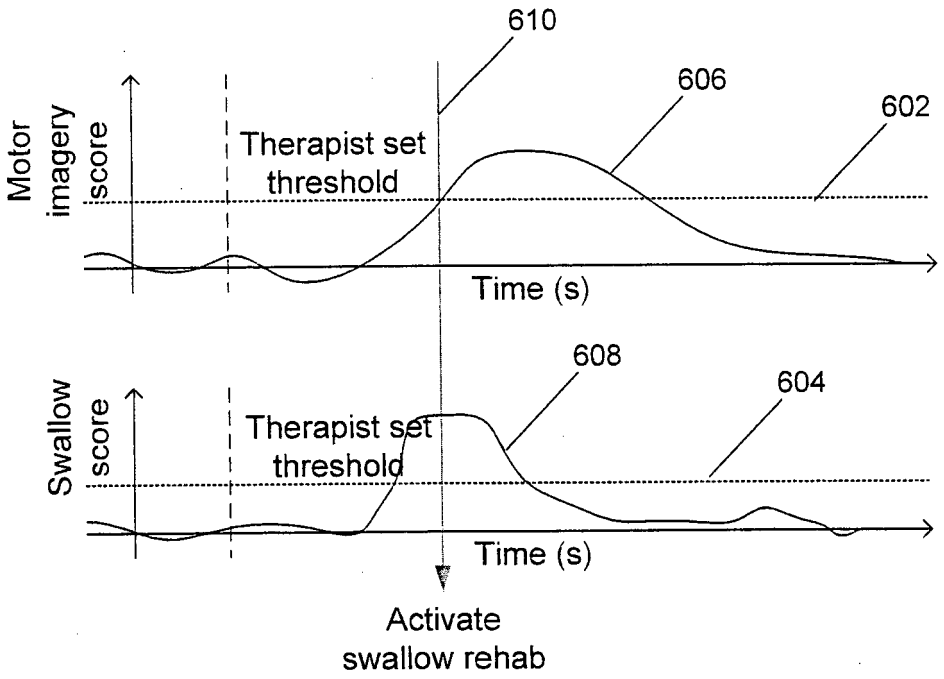

610
606
602
Motor imagery score
Therapist set threshold
Time (s)
608
604
Swallow score
Therapist set threshold
Time (s)
Activate swallow rehab

Figure 6

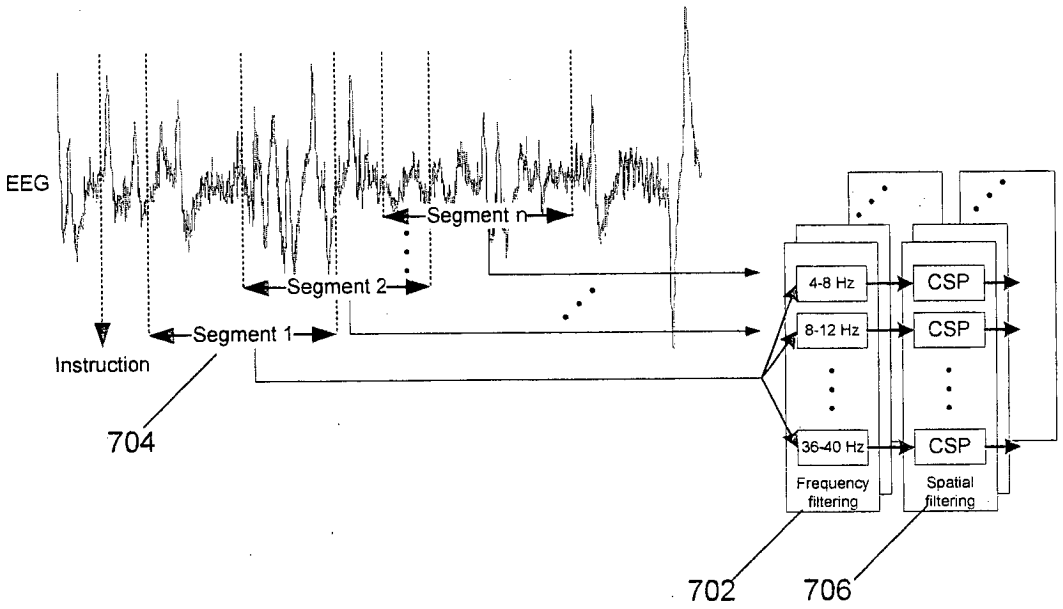

EEG
Segment n
Segment 2
Segment 1
Instruction
704
4-8 Hz
8-12 Hz
36-40 Hz
CSP
CSP
CSP
Frequency filtering
Spatial filtering
702
706

Figure 7

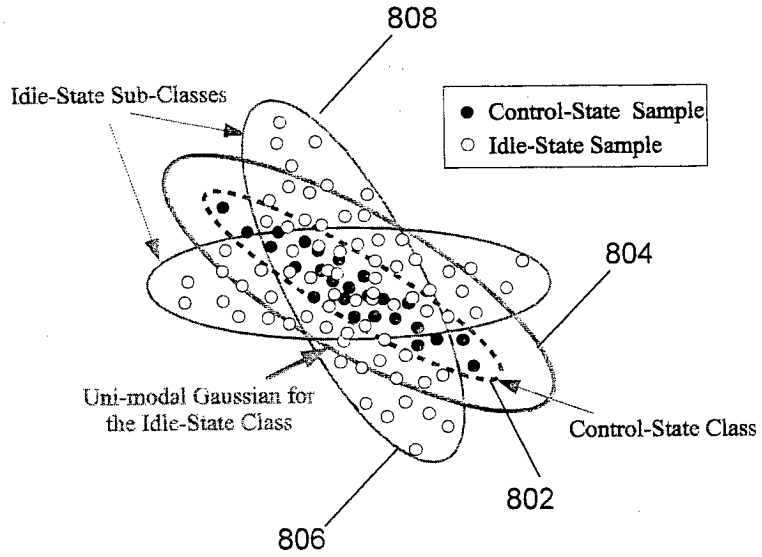

808
Idle-State Sub-Classes
Control-State Sample
Idle-State Sample
804
Uni-modal Gaussian for
the Idle-State Class
Control-State Class
802
806

Figure 8

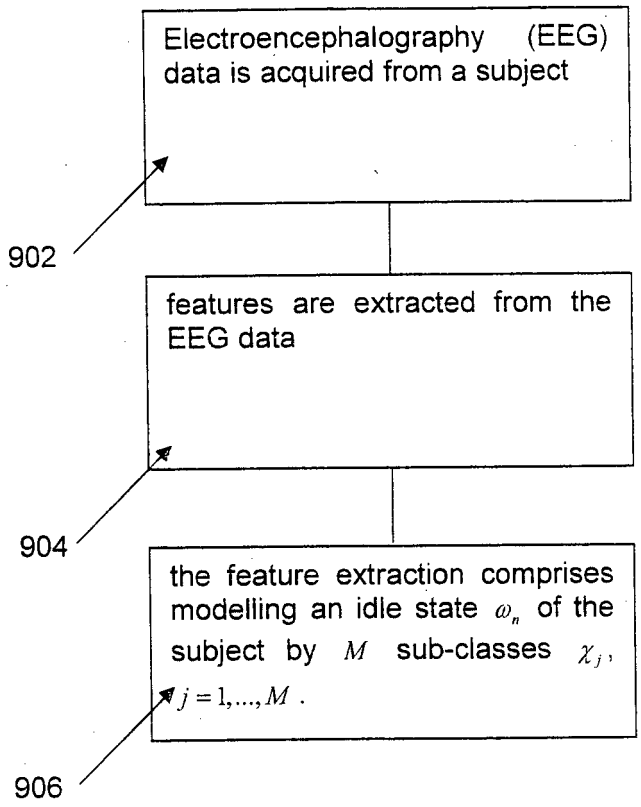

Electroencephalography (EEG) data is acquired from a subject
902
features are extracted from the EEG data
904
the feature extraction comprises modelling an idle state ω_n of the subject by M sub-classes χ_j, $j = 1,...,M$.
906
900

Figure 9

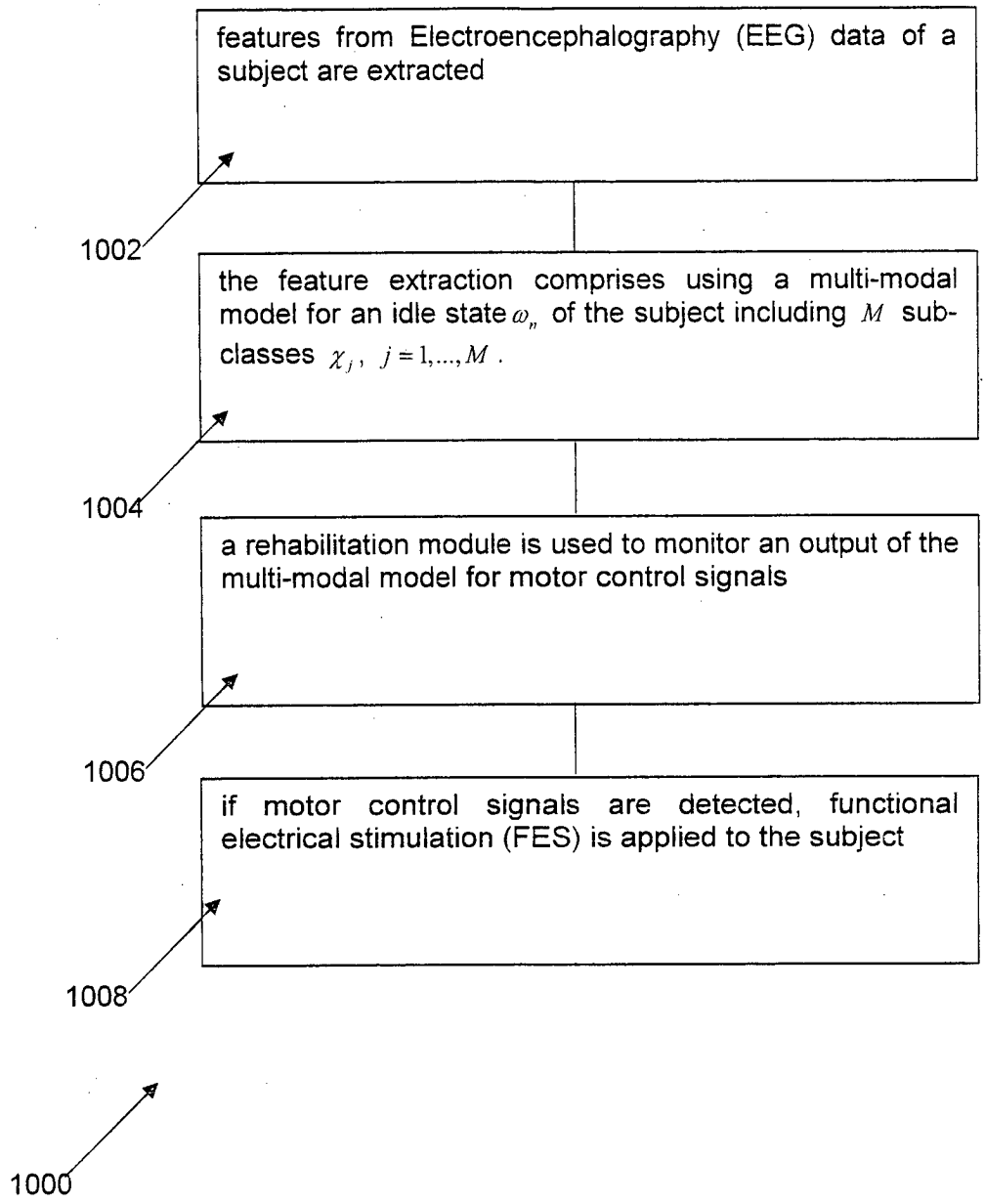

features from Electroencephalography (EEG) data of a subject are extracted
1002
the feature extraction comprises using a multi-modal model for an idle state ω_n of the subject including M sub-classes χ_j, $j = 1,...,M$.
1004
a rehabilitation module is used to monitor an output of the multi-modal model for motor control signals
1006
if motor control signals are detected, functional electrical stimulation (FES) is applied to the subject
1008
1000

Figure 10

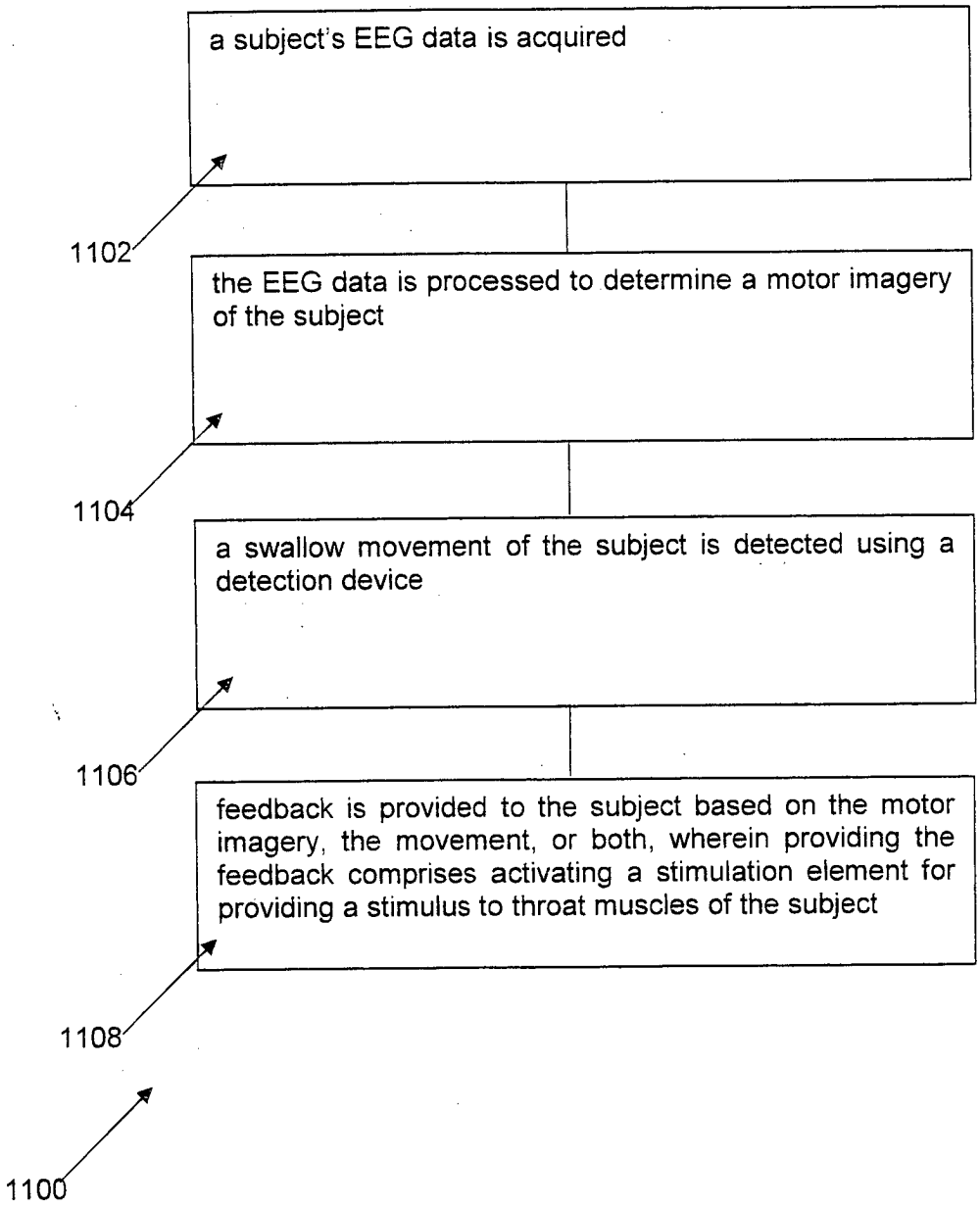

a subject's EEG data is acquired
1102
the EEG data is processed to determine a motor imagery of the subject
1104
a swallow movement of the subject is detected using a detection device
1106
feedback is provided to the subject based on the motor imagery, the movement, or both, wherein providing the feedback comprises activating a stimulation element for providing a stimulus to throat muscles of the subject
1108
1100

Figure 11

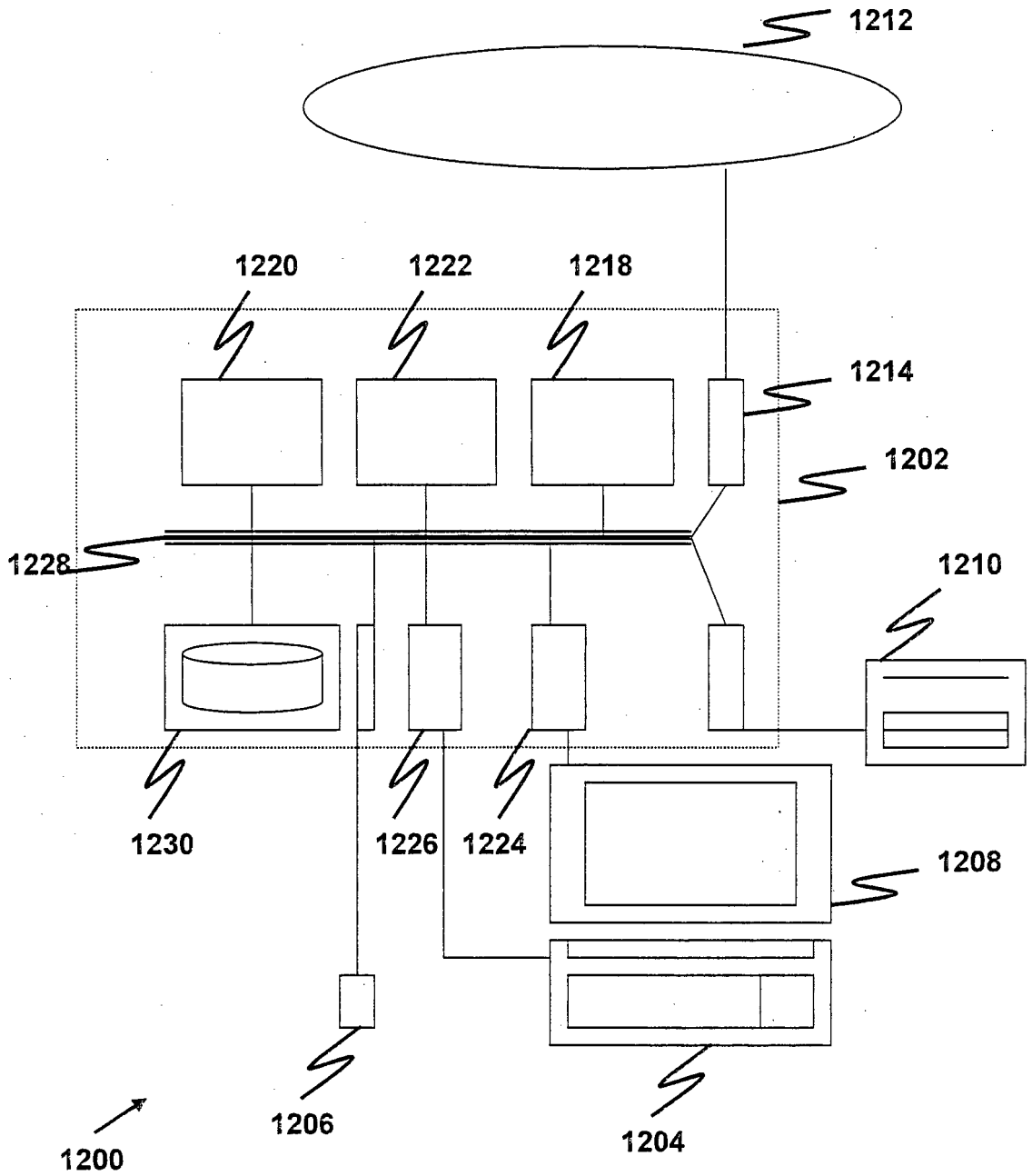

1212
1220
1222
1218
1214
1202
1228
1210
1230
1226
1224
1208
1206
1204
1200

Figure 12