(54) Title: METHOD FOR OPERATING A SPEECH RECOGNITION SYSTEM

(57) **Abstract:** A method for operating a speech recognition system is described in which a speech signal (S_I) of a user is detected and analyzed so as to recognize speech information contained in the speech signal (S_I). The speech recognition system determines a reception quality value (S_Q) or a noise value which represents a current reception quality. The speech recognition system is switched over to a mode of operation which is less sensitive to noise and/or outputs an alert signal (S_W) to the user when the reception quality value (S_Q) drops below a given reception quality threshold or when the noise value exceeds a noise threshold. An appropriate speech recognition system is also described.

Method for operating a speech recognition system

The invention relates to a method for operating a speech recognition system, in which method a speech signal of a user is detected and analyzed so as to recognize speech information contained in the speech signal. The invention also relates to a speech recognition system which comprises means for the detection of a speech signal of a user and a speech

5   recognition device for analyzing the detected speech signal so as to recognize speech information contained in the speech signal.

Speech recognition systems are used increasingly in many fields of application in order to enable speech communication between a user and the relevant application, for example, an apparatus control or an automatic information service. Such speech-user

10   interfaces have many advantages. On the one hand, generally speaking, they make hands-free operation of apparatus possible. On the other hand, they are also suitable in particular as user interfaces for partially sighted or otherwise physically handicapped persons who are not capable of reading optical displays and/or of operating input means such as a keyboard or a mouse and, therefore, have to rely on speech as a communication means. Furthermore,

15   interfaces of this kind are used increasingly in automatic speech dialog systems. Examples of such speech dialog systems are automatic answering and information systems which nowadays are used in particular by some large companies and public services so as to offer a caller as quickly and as comfortably as possible with the desired information or to connect the caller to a station responsible for the special requests from the caller. Further examples in

20   this respect are automatic telephone information systems, navigation systems, information services with general agenda topics or cinema and theater programs as well as arbitrary combinations of the various information systems.

The speech signal is transferred from the user to the speech recognition system in different ways or via different apparatus in dependence on the relevant application in

25   which the speech recognition system is used. In the case of stationary dialog systems, for example, in information terminals in public places such as railway stations, airports, museums etc., the speech recognition system comprises one or more receiving channels whereto the appropriate microphones, headsets or the like are connected so as to enable the user to communicate with the terminal or the speech recognition system. The previously

described automatic speech dialog systems, however, customarily can be accessed via a communication network, for example, a telephone network or the Internet, by using appropriate terminals of the user. Consequently, in that case the speech signal of the user is first detected by the terminal, after which it is converted into electrical signals and applied to

5   a terminal of the speech dialog system via a speech and/or data channel of the communication network.

It is inherent of notably speech recognition systems which can be contacted by the users from an arbitrary environment by means of a communication terminal that the reception quality with which the speech signal is received can vary strongly, that is, even

10   strongly within a session. The reception quality is then determined to a substantial extent by on the one hand the quality of the transmission channel, for example, the telephone link, as well as on the other hand by the background noise level which itself is dependent on the environment in which the user is present at the relevant instant. It will be evident that as the reception quality is less, the operating conditions for the speech recognition system will also

15   be less favorable, because secondary noise or brief disturbances or interruptions of the transmission channel are liable to corrupt the recognition result. As the reception quality deteriorates further, sooner or later (depending on the sensitivity of the speech recognition system) the speech recognition system will hardly be capable of delivering recognition results that are satisfactory to some extent. It is in a drawback that exactly the speech recognition

20   systems which respond as quickly and as naturally as possible to an utterance of a user, and hence are very comfortable per se for the user, react very sensitively to disturbances. On the other hand, speech recognition systems which, for example, allow the input of speech utterances by the user only at given, exactly defined instants, require a given, comparatively high volume during the speech input and respond comparatively slowly to utterances, are

25   more robust in respect of a deterioration of the reception quality.

It is an object of the present invention to improve a method for operating a speech recognition system or a speech recognition system of the kind set forth in such a manner that it continues to operate with an as high as possible quality also in the event of a deterioration of the reception quality and still offers the user the maximum possible comfort.

30   This object is achieved in that there is determined a reception quality value or a noise value which represents a current reception quality, and in that the speech recognition system switches over to a mode of operation which is less sensitive to noise and/or outputs an alert signal to the user when the reception quality value drops below a given reception quality threshold or when the noise value exceeds a noise threshold.

Because the monitoring of a reception quality value in respect of this value dropping below a given reception quality threshold is identical, except for the use of reciprocal values as well as the corresponding reversal of the limit condition, to the monitoring of a noise value, for example, the level of a background noise signal, in respect of

5   this value exceeding a given noise threshold, hereinafter the invention will be described in general only on the basis of the first version for the sake of simplicity, however, without the invention being restricted thereby in any way. The corresponding terms of the two versions can be interchanged at all times in the following description.

The invention enables an appropriate response of the speech recognition

10   system itself and/or of the user to a deterioration of the reception quality, so that the user can always be offered the maximum feasible comfort in the current reception conditions while on the other hand it is ensured that as the reception conditions become worse, the quality of the recognition results is not degraded excessively.

For the response of the speech recognition system itself it is arranged that the

15   speech recognition system switches over to a more robust mode of operation in which the reception quality has less effect on the quality of the speech recognition. For example, a voice activity detector, first detecting the incoming speech signal, could be switched to a less sensitive mode or waiting periods, elapsing until a response of the speech recognition system takes place, could be prolonged so that the speech recognition system overall no longer

20   responds so quickly to any secondary noise. Alternatively, or additionally, an alert signal is output to the user, said alert signal preferably being a more elaborate warning message in the form of a speech signal output by the speech recognition system, so that the user himself or herself can also respond to the deterioration of the reception quality and, for example, move to a quieter environment or, when a mobile radio apparatus is used, improve the mobile radio

25   connection by searching a suitable location.

A wide variety of combinations of the two methods of responding is feasible. For example, only an alert signal can be issued to the user or only automatic switching over to a less sensitive mode of operation can be carried out. However, simultaneously with the switching over to the more robust mode of operation an alert signal may be output to the user,

30   said alert signal preferably containing the indication that the mode of operation has been switched over. Furthermore, it is also possible that initially only the alert signal is output to the user and that, for example, when the reception quality does not improve or deteriorates even further, switching over to the less sensitive mode of operation takes place after a given period of time.

The reception quality threshold may then also be defined so as to be variable in dependence on given parameters of the relevant application, for example, in dependence on the possible consequences of incorrect recognition of a speech signal. It is notably also possible to define a plurality of different reception quality thresholds and to activate in steps

5   different modes of operation and/or to output alert signals to the user each time in dependence on said reception quality thresholds.

In a particularly advantageous embodiment the speech recognition system is automatically reset to the previous mode of operation when the reception quality value exceeds the reception quality threshold again. This means that the speech recognition system,

10   for example, automatically becomes more sensitive again so that it responds more comfortably for the user as soon as the user has successfully created a better reception quality in response to the alert signal, or when the reception quality becomes better again for other reasons.

In a particularly advantageous embodiment a so-called barge-in mode of

15   operation of the speech recognition system is switched off as soon as the reception quality drops below the reception quality threshold. This means that the speech recognition system switches over from a mode of operation in which the user has the possibility of barging in on the speech output of the speech recognition system (so-called prompts), to an "alternative" mode of operation in which the user must first await the complete output of the prompt

20   before the user can react to the prompt of the speech recognition system. Barge-in speech recognition systems of this kind on the one hand offer the advantage that in comparison with the "alternative" systems for the user they respond substantially more naturally, that is, like a "true" interlocutor. On the other hand, an experienced user can operate such a speech recognition system substantially faster, because often the user already knows the prompts to

25   be output so that the user can interrupt the output of the prompt by a premature response, thus substantially reducing the duration of the overall dialog.

A reception quality value can be determined in a variety of ways.

It is particularly simple to determine a reception quality value by means of a voice activity detector which, generally speaking, is already used at the input of the speech

30   recognition system for the detection of first of all the incoming speech signal as such and to conduct it to the actual speech recognition device. The reception quality value can then be determined, for example, on the basis of a background signal received in a speech pause of the user. This means that, for example, a noise level or the basic signal energy is measured at the input during the speech pauses so as to be used as a measure of the reception quality. For

example, it can thus be determined whether the user is present in a quiet or in a noisy
environment. Furthermore, the reception quality value can also be determined by means of
the actual speech recognition device itself, for example, on the basis of confidence values
obtained for the recognition results or on the basis of other parameters which are dependent,
5   for example, on the quality of the recognition result or on the effort made for the recognition.

The actual processing of the reception quality value within the speech
recognition system can then also take place in variety of ways.

On the one hand, the voice activity detector can apply the reception quality
value itself, for example, to a dialog control device. In this case, for example, a programmer
10   of the relevant application, who configures the dialog control device in conformity with the
relevant application, can specify as from which reception quality threshold the speech
recognition system should react in what way or which prompts are to be output to the user.

Alternatively, or additionally, it is also possible for the voice activity detector
to output a reception corruption indication signal to the dialog control device and/or other
15   components of the system when the reception quality value drops below the reception quality
threshold. The dialog control device can then respond accordingly to the reception corruption
indication signal and output, for example, an appropriate prompt to the user. Moreover, the
mode of operation can be changed via the dialog control device and/or the further system
components.

20   In a particularly comfortable system an incoming signal is analyzed in more
detail in respect of the type of disturbance causing the reception quality value to be below the
reception quality threshold. In that case the user is provided with an alert signal in the form of
a prompt which contains the relevant information. This means that an analysis is performed,
for example, as to whether a poor connection between a communication terminal of the user
25   and the speech recognition system is concerned or whether the background noise in the
vicinity of the user is too loud. When the user receives the corresponding information, it will
be easier for the user to react correctly so as to improve the reception quality. This analysis
can be performed inter alia by means of the voice activity detector and/or the actual speech
recognition device.

30   In order to carry out the method in accordance with the invention, a speech
recognition system in accordance with the invention should comprise on the one hand an
appropriate quality control device for determining a corresponding reception quality value or
a noise value. On the other hand, the speech recognition system should comprise a
comparator for comparing the reception quality value with a given reception quality threshold

6

or for comparing the noise value with a given noise threshold. Finally, a speech recognition system of this kind requires appropriate control means, for example, a switching device or a suitably programmed dialog control device for switching over the speech recognition system to a mode of operation which is less sensitive to noise and/or to output an alert signal to the

5   user when the reception quality value drops below a given reception quality threshold or when the noise value exceeds the noise threshold. The comparator may also be integrated in other components of the system, for example, in the voice activity detector or in the dialog control device.

           A speech recognition system in accordance with the invention preferably is

10   implemented to a high degree on a computer or in a speech control of an apparatus by means of suitable software. For example, the speech recognition device and the dialog control device can be realized completely in the form of software modules. A device for generating the appropriate prompts, for example, a so-called TTS converter (text-to-speech converter) can also be realized by means of suitable software. It is alternatively possible to use a prompt

15   player which reproduces given, previously recorded prompts for the user. It is necessary, of course, that the system comprises facilities for speech input and speech output; such facilities are to be realized in the form of hardware, for example, a microphone and a loudspeaker or an interface for connection to a communication network via which the speech recognition system can be accessed by way of a terminal.

20   It is notably also possible that instead of the speech recognition system being realized within a single apparatus, for example, on a single server, various components of the system are situated in different locations which are connected to one another via an appropriate network. The speech recognition system in accordance with the invention can be used in conjunction with applications of all kinds. In particular it can also be made available

25   to a plurality of applications simultaneously, that is, as a service system, for example, in the form of a time sharing system, so that it forms a respective user interface for the various applications.

30   The invention will be described in detail hereinafter on the basis of two embodiments and with reference to the accompanying drawings. Therein:

           Fig. 1 shows a block diagram of a first embodiment of a speech recognition system in accordance with the invention, and

Fig. 2 shows a block diagram of a second embodiment of a speech recognition system in accordance with the invention.

5   The embodiments shown in the two Figures both are a speech recognition system 1 of the so-called "barge-in" type.

A microphone 2 is connected to each speech recognition system 1 in order to input a speech signal S_1. For the output of acoustic signals or speech output (prompts) to the user a respective loudspeaker 3 is connected to the speech recognition systems 1.

10   Alternatively, the microphone 2 and the loudspeaker 3 may also be present in a terminal which is remote from the speech recognition system 1 itself and is connected to the speech recognition system 1 via a suitable interface, for example, a telephone network or the like.

An input signal from the microphone 2 in both speech recognition systems 1 reaches first of all an echo filter 4 which is also referred to as echo cancellator. In cases

15   where the user speaks even though a prompt S_O is still being output by the speech recognition system 1 itself, this echo filter 4 serves to remove the echo of the prompt S_O, which echo may be superposed on the speech signal S_1 in attenuated form, from the input signal.

The speech signal S_1 is then applied to a voice activity detector 5 which measures the signal energy and hence the voice activity of the user. This voice activity

20   detector 5 serves on the one hand to detect the beginning and the end of a speech signal as well as speech pauses within an utterance of the user. On the other hand, this voice activity detector outputs a barge-in signal S_{BI} which is applied to a text-to-speech converter 8 (referred to hereinafter as TTS converter 8) and to a dialog control device 10 in order to prevent the further output of the prompt by the TTS converter 8 in cases where a user barges

25   into a prompt still being output.

In the present case a barge-in switching unit 9 is inserted in the output lead for the barge-in signal S_{BI} of the voice activity detector 5. The system 1 is actually suitable for barging in exclusively when this barge-in switching unit 9 is in the closed state. When the switch is open (the state shown in Fig. 1), the speech recognition system 1, however, does not

30   react to speech input of the user during the output of a prompt.

From the voice activity detector 5 the speech signal S_I itself is applied to an automatic speech recognition device 7 in which the actual analysis of the speech signal S_I is carried out so as to recognize the speech information contained therein. The recognition

result is then applied, in the form of text or in another machine-readable form, to the dialog control device 10.

Finally, the dialog control device 10 responds to the recognition result in a predetermined manner, that is, in conformity with a given dialog protocol, and, for example,

5   selects from a memory 12 information desired by the user or stores data entered by the user therein. Moreover, the dialog control device drives the TTS converter 8 and supplies the converter with the data for the prompts to be output to the user. The prompts are then applied from the TTS converter 8, via the echo filter 4, to the loudspeaker 3 via which they are output. The exact construction of the dialogue control device 10, generally speaking, is

10   dependent on the relevant application.

In accordance with the invention both embodiments shown in the drawings comprise, in addition to a barge-in switching unit 9, a quality control device 6 which forms part of the voice activity detector 5. A reception quality value S_Q is determined in said quality control device 6. This signal may be, for example, the reciprocal value of a background noise

15   level which is measured by the voice activity detector 5 prior to the beginning of the utterance and/or in the speech pauses of the user.

The reception quality value S_Q is applied to the dialog control device 10 which compares the reception quality value S_Q with a predetermined reception quality threshold in a comparator 11, for example, realized in the form of a software module, with a predetermined

20   reception quality threshold. As soon as the reception quality value S_Q is below the predetermined threshold, the dialog control device 10 applies a barge-in deactivation signal S_{BA} to the barge-in switching unit 9 in which the switch is set to the position shown in Fig. 1. This means that the speech recognition system 1 is switched over from a mode of operation in which barging in is permissible to a mode of operation in which barging in is not

25   permissible. This offers the advantage that in the case of an excessively high background noise threshold during the output of a prompt, the speech recognition system 1 will not be continuously interrupted because of background noise which is not associated with the user and should not lead to an interruption of the prompt. This means that the speech recognition system 1 is switched over to a mode of operation which admittedly leads to a type of dialog

30   which is slightly less natural and hence less comfortable type for the user, but which is substantially more robust and substantially better suitable for the reception conditions occurring at the relevant instant.

Moreover, as soon as the reception quality value S_Q drops below the predetermined reception quality threshold, the dialog control unit 10 ensures that the TTS

9

generator 8 generates and outputs a relevant alert signal in the form of a suitable alert prompt S_W, for example, a message of the type "The background noise is too loud. Please wait for completion of the output of a prompt before responding".

The dialog control device 10 is arranged in such a manner that, when the reception quality value S_Q increases beyond the predetermined reception quality threshold again, it automatically cancels the barge-in deactivation signal S_{BA}, thus closing the switch in the barge-in switching unit 9 again.

It is in principle up to the programmer of the dialog control device 10 to define arbitrary reception quality thresholds as from which a barge-in state is deactivated and/or at which an alert signal is issued to the user so that, if necessary, the user can look for a quieter environment in as far as possible.

Fig. 2 shows a slightly different embodiment of a speech recognition system 1 in accordance with the invention.

In this embodiment the reception quality value S_Q is compared with the reception quality threshold directly in the quality control device 6; this means that the comparator 11 is integrated in the quality control device 6. When the quality control value drops below the predetermined reception quality threshold, the quality control device 6 outputs a reception corruption indication signal S_{EB} which at the same time deactivates the barge-in switching unit 9 and is applied to the dialog control device 10 in order to ensure that, in dependence on the programming, the output of a suitable alert prompt S_W via the TTS converter 8 is initiated.

It is to be noted again that the speech recognition systems 1 shown in the figures are merely special embodiments of the invention and that a person skilled in the art will be capable of modifying the speech recognition systems 1 or the method for operating the speech recognition systems 1 in various manners without departing from the scope of the present invention.

For example, it is notably possible for the quality control unit 6 to form a part of the dialog control device 10. Moreover, the barge-in switching device 9 may also form a part of the voice activity detector 5 or the dialog control device 10 and be constructed, for example, also as a pure software switch. Furthermore, the quality control unit 6 may also be constructed as an independent, pure hardware module. Moreover, the speech recognition system may comprise additional components or further functions; for example, it may execute an intelligent, grammar-based barge-in method. In that case the barge-in signal is not generated already by the voice activity detector, but only by the speech recognition device

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which first checks whether an incoming signal actually has a content that makes sense and hence is to be considered as a barge-in event. Further variations may comprise, for example, speaker identification or other elaborations of the speech recognition system.

CLAIMS:

1.   A method for operating a speech recognition system (1), in which method a
speech signal (S$_I$) of a user is detected and analyzed so as to recognize speech information
contained in the speech signal (S$_I$), characterized in that there is determined a reception
quality value (S$_Q$) or a noise value which represents a current reception quality, and in that
5   the speech recognition system (1) switches over to a mode of operation which is less
sensitive to noise and/or outputs an alert signal (S$_W$) to the user when the reception quality
value (S$_Q$) drops below a given reception quality threshold or when the noise value exceeds a
noise threshold.

10   2.   A method as claimed in claim 1, characterized in that the speech recognition
system is automatically reset to the previous mode of operation when the reception quality
value (S$_Q$) exceeds the reception quality threshold again or when the noise value drops below
the noise threshold again.

15   3.   A method as claimed in claim 1 or 2, characterized in that when the reception
quality value drops below the reception quality threshold or the noise value exceeds the noise
threshold, a barge-in mode of operation of the speech recognition system (1) is deactivated.

4.   A method as claimed in one of the claims 1 to 3, characterized in that the
20   reception quality value (S$_Q$) or the noise value is determined by means of a voice activity
detector (5).

5.   A method as claimed in one of the claims 1 to 4, characterized in that the
reception quality value (S$_Q$) or the noise value is determined on the basis of a background
25   signal which is received prior to the beginning of the utterance and/or in a speech pause of
the user.

6.   A method as claimed in claim 4 or 5, characterized in that the voice activity
detector (5) applies the reception quality value (S$_Q$) or the noise value itself and/or, when the

reception quality value drops below the reception quality threshold or when the noise value exceeds the noise threshold, a reception corruption indication signal (S_{EB}) to a dialog control device (10).

5   7.   A method as claimed in one of the claims 1 to 6, characterized in that when the reception corruption indication signal (S_{EB}) is received and/or when the received reception quality value (S_Q) drops below the reception quality threshold or the noise value exceeds the noise threshold, the dialog control device (10) initiates the output of a prompt (S_W) to the user who is thus given the information that the reception conditions are poor.

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       8.   A method as claimed in one of the claims 1 to 7, characterized in that an incoming signal is analyzed as regards the type of disturbance causing the reception quality value (S_Q) to be below the reception quality threshold or the noise value to be above the noise threshold, and that a prompt (S_W) which contains this information is output to the user.

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       9.   A speech recognition system (1) which comprises means (5) for the detection of a speech signal (S_I) of a user and a speech recognition device (7) for analyzing the detected speech signal (S_I) so as to recognize speech information contained in the speech signal, characterized in that it comprises a quality control device (6) for determining a

20   reception quality value (S_Q) or a noise value, representing a current reception quality,

                a comparator for comparing the reception quality value (S_Q) with a predetermined reception quality threshold or for comparing the noise value with a given noise threshold,

                and control means (9, 10) which are constructed in such a manner that the

25   speech recognition system (1) is switched over to a mode of operation which is less sensitive to noise and/or an alert signal (S_W) is output to the user when the reception quality value drops below the reception quality threshold or when the noise value exceeds the noise threshold.

30   10.   A computer program which comprises program code means for carrying out all steps of a method as claimed in one of the claims 1 to 8 when the program is run on a computer.
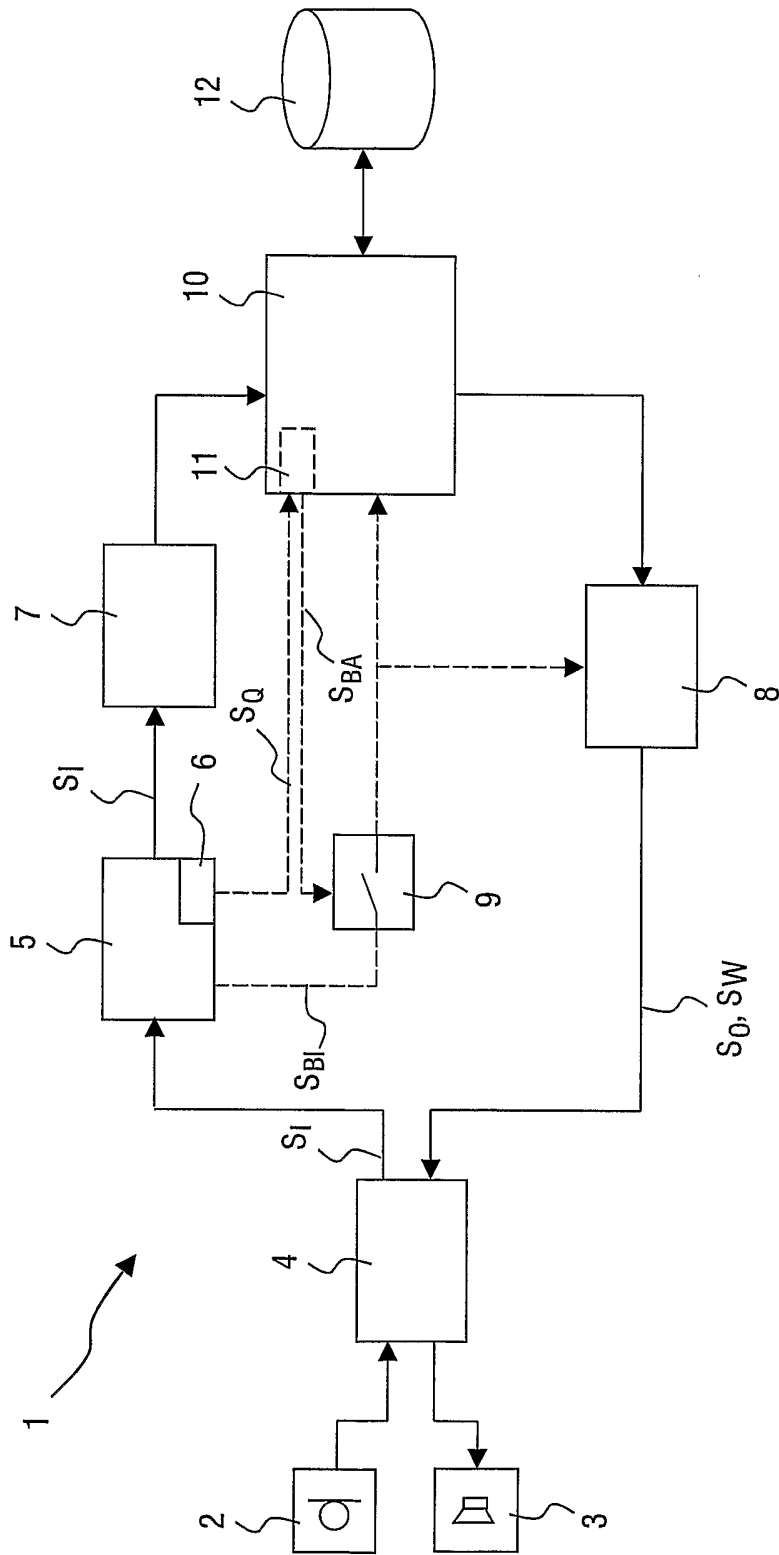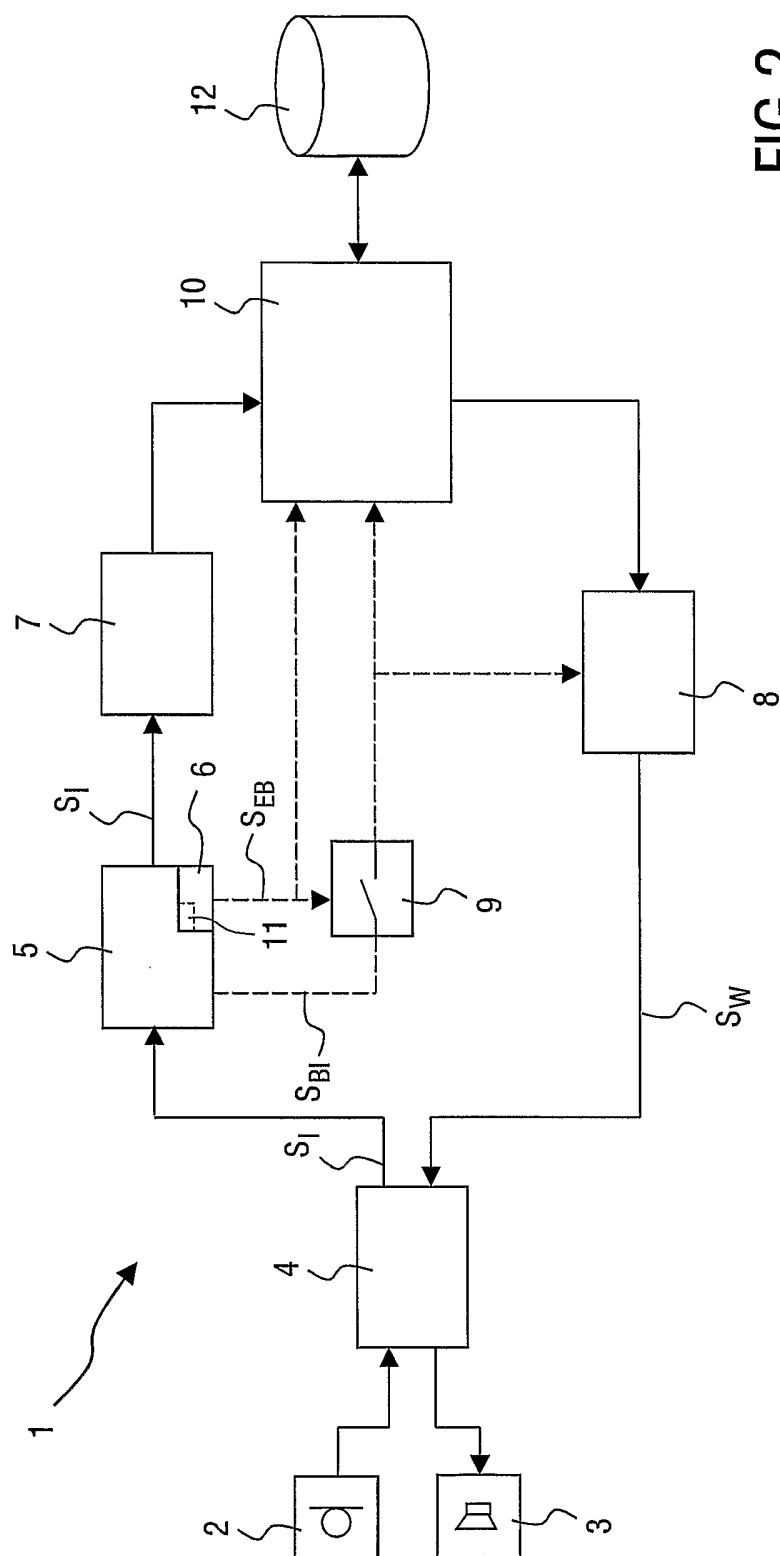
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FIG.1

2/2

FIG.2

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7   G10L15/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7   G10L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, INSPEC, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 00/72307 A (BOVES LODEWIJK WILLEM JOHAN ; KONINKL KPN NV (NL); DRENTH EGBERT WILLE) 30 November 2000 (2000-11-30) abstract page 2, line 38 - page 3, line 9	1,4,6, 8-10
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[X] Further documents are listed in the continuation of box C.　　　　[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 January 2004	04/02/2004

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European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Quélavoine, R

INTERNATIONAL SEARCH REPORT

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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