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Description

Technical field

The invention relates to the control of laboratory devices, and in particular the control of complex laboratory systems.

Prior art

In chemical laboratories, a large number of rules to ensure safe working therein are in force on account of various hazards arising from both substances and devices. Depending on the type of laboratory, the activities carried out therein and the substances used, the following safety regulations, inter alia, can therefore predominate: personal protective equipment needs to be worn, which can comprise protective goggles or a protective mask and also protective gloves in addition to a lab coat. Carrying and consuming food and drink is not normally permitted, and, to avoid contamination, the office area with a desk, manuals, product documentation in paper form, computer workstation and Internet access and the laboratory work area are physically separate from one another. The physical separation can provide for crossing between office area and laboratory area to be possible only via a security door system. It may also be a regulation to remove safety clothing when leaving the laboratory area.

Safety regulations hamper workflow considerably in some cases: laboratory devices, and in particular complex laboratory systems having multiple laboratory devices, provide the user with a separate user interface that often consists of a screen, mouse and keyboard and/or a touchscreen. These are often standard device components that are impossible or difficult to use with laboratory gloves. There is an increased occurrence of input errors that slow down the workflow and can also lead to erroneous control and use of the laboratory device. Removing gloves before using the laboratory system carries a contamination risk, slows

down work and is sometimes not possible in the first place for safety reasons.

In individual cases, there are laboratory devices having a particularly large keyboard, for example in the form of a large touchscreen, in order to facilitate input with gloves. This special hardware is expensive, however, and not available for all laboratory devices. In particular, standard computers and standard notebooks do not have a "glove-friendly" keyboard of this kind. The option of being able to also use standard computers with a conventional Internet browser is becoming increasingly important in the laboratory context, however, for instance in order to be able to search chemical databases available online.

Currently available options for controlling and interacting with laboratory devices and laboratory systems within the context of a chemical or biological laboratory are very limited and inefficient.

The document US 2015/0127270 A1 describes a laboratory system that permits automatic processing of samples and is able to compile data relating to said samples. Voice control is possible in this context. The document US 2013/0266952 A1 relates to a laboratory device for handling liquids that is able to be controlled by means of voice input using a mobile phone. The document DE 102014005549 A1 relates to a system for monitoring reaction vessels in touch-free fashion. Reagent vessels are identified by means of RFID chips in this case.

Summary

It is an aim of the present invention to provide an improved laboratory system and method for controlling at least one laboratory device or a laboratory software module in accordance with the independent claims that allow improved speech-to-text conversion, in particular in the laboratory context. Embodiments of the invention are specified in the dependent claims.

Embodiments of the present invention can be freely combined with one another if they are not mutually exclusive.

In one aspect, the invention relates to a laboratory system. The laboratory system contains at least one laboratory device designed for analysing and/or synthesizing a chemical substance. The laboratory system further contains at least one laboratory software module designed for processing data obtained from the at least one laboratory device. The laboratory system further contains a data processing device having supervisory software that provides an interface for using the at least one laboratory device and/or the at least one laboratory software module. The laboratory system further contains a portable device having a microphone. The device is interoperably connected to the supervisory software via a network and is designed to interoperate with the supervisory software in order to allow a user to use the at least one laboratory device and/or the at least one laboratory software module in contact-free fashion by means of voice input into the microphone.

This enables allow facilitated and improved supervision and control of laboratory devices, e.g. in biological and chemical laboratories, by one or more people. Since the laboratory devices and the associated laboratory software modules are controlled by means of a voice input, it is not necessary for gloves to be removed or for other time-consuming measures to be taken in order to input control commands. The voice-based input permits information to be input at any location in audible range of the portable device, in particular within a laboratory area. The person making the voice input thus does not have to leave their laboratory workstation, or has the option of moving freely between different workstations in the laboratory area, so long as he does not leave the receiving area of the microphone of the portable device in that event.

Control of target systems by means of voice input is known per se. As such, there are beneficial terminals on the market that have a microphone and powerful applications for voice-based

input of commands, for example Echo Dot with Alexa (Amazon), smart speakers from various manufacturers with Cortana (Microsoft), Google Home Max/Mini with the Google Assistant (Google) and HomePod with Siri (Apple). However, these are designed to assist end users in everyday activities such as for example shopping, selecting a radio station or booking a hotel. Said terminals and applications are therefore designed for everyday situations and also support only general-language words. The existing terminals are neither designed nor suitable for use in a laboratory and for recognizing technical words. The terminals commercially available today are additionally not designed to be subsequently modified by the user, which means that a user has no way of using the smart speaker systems with voice recognition that are currently available on the market for use in the laboratory area.

The supervisory software of the laboratory system is configured according to the invention to receive from the portable device a voice signal that the microphone has picked up on the basis of the voice input. The voice signal contains general-language and technical-language words spoken by the user. The supervisory software is further configured to input the received voice signal into a voice-to-text conversion system, wherein the voice-to-text conversion system supports only the conversion of voice signals into a target vocabulary that does not contain the technical-language words. The supervisory software then receives from the voice-to-text conversion system a text that was generated from the voice signal by the voice-to-text conversion system. The supervisory software is further configured to generate a corrected text from the received text, wherein the corrected text is generated by the supervisory software alone or by the supervisory software by means of interpretation with text correction software to which the supervisory software is operatively connected locally or via a network. The corrected text is generated by automatically replacing words and expressions from the target vocabulary in the received text with technical-language words in accordance with an association table of words in text form. The association table associates at least

one word from the target vocabulary with each of a multiplicity of technical-language words. The at least one word from the target vocabulary that is associated with a technical-language word is a word or expression that the voice-to-text conversion system incorrectly identifies when this technical-language word is input in the form of a voice signal. The supervisory software is configured to use the corrected text to prompt the at least one laboratory device and/or the at least one laboratory software module to perform the analysis, synthesis and/or software function in accordance with statements in the corrected text.

Supervisory software has been developed that is capable, alone or in interoperation with further components, of correctly converting even voice inputs having technical-language words into text, and a portable device having a microphone has been developed that is interoperable with this supervisory software. Therefore, a laboratory system has been provided that allows voice-based control of laboratory devices and associated laboratory software modules in a similarly simple and contact-free manner to what is possible in smart homes today on the basis of Amazon’s Echo Dot, for example.

The use of a voice-to-text conversion system that does not support technical words in combination with subsequent correction of the text on the basis of the association table can be advantageous for several reasons.

First, there are already a series of general-language voice-to-text conversion systems, e.g. Google’s “Speech to Text”, which have a high level of accuracy at least for general-language words and expressions and in some cases are usable at no cost and integrable into proprietary software programs via an open API. A voice input in the laboratory context normally comprises a mixture of technical words and general-language words, so that at least correct conversion of the general-language words into text is ensured. The voice-to-text conversion systems from Google and other cloud service providers are continually being

developed further, a service that the manufacturers of laboratory devices and laboratory management systems normally cannot provide in the quality possible for the large cloud service providers such as Google, Amazon and Apple.

However, said general-language voice-to-text conversion systems are per se not suitable for use in the laboratory context, since technical-language words ("technical words") are not supported by the voice-to-text conversion system. In biology and in the chemical industry, in particular, a multiplicity of technical words that do not occur in general language are used in the laboratory context. These are not recognized by the voice-to-text conversion system; instead, similarly sounding general-language words are therefore incorrectly identified and converted into text. Specifically in the context of a chemical laboratory, however, a high level of precision in the voice recognition is of particular importance. Whereas minor errors are often recognizable as such in everyday language and can easily be corrected or compensated for by the user or receiver system (for example incorrect recognition of the singular/plural form does not result in a corresponding input into an Internet search engine returning substantially different results), even the slightest deviations (e.g. "bis" instead of "tris") in the context of chemical syntheses can result in a completely different substance being "recognized" than the substance that was actually meant by the speaker, and the resulting product being unusable. Said voice-to-text conversion systems designed for everyday use are therefore not suitable for use in biological and chemical laboratories.

In some instances, there are voice-to-text conversion systems that are specifically designed for the requirements and vocabulary of a particular field. For example the Nuance company offers the "Dragon Legal" software for lawyers, which, in addition to everyday-language vocabulary, also comprises legal technical terms. However, the disadvantage is that the vocabulary required in a specific laboratory, e.g. in the field of manufacturing and analysing dyes and paints, is so

specifically and dynamically variable that even voice recognition software containing chemical terms, which could, for instance, be taken from a standard chemistry textbook, would often be unsuitable for the practice of a specific company or a specific branch of the chemical industry, since work is often also carried out in a laboratory using trade names of substances. These trade names can change or a multiplicity of new trade names for relevant products are added every year. In particular, a multiplicity of further products and product variations under new trade names, which can be used for the manufacture of dyes and paints, appear on the market every year. Even if there were a voice-to-text conversion system that came close to the exactness of the everyday-language systems from Google or Apple and comprised the most important chemical technical terms (which is not the case), this system would not be very suitable for use in practice on account of the dynamics and multiplicity of names that play a role in a chemical laboratory in practice, in particular when manufacturing dyes and paints, since most words relevant to practice would not be supported or the vocabulary would be completely out of date at least after a few years.

According to embodiments of the invention, this problem is solved as described above by resorting to a voice-to-text conversion system which is known not to support the relevant technical terms. Therefore, there is no attempt from the outset to implement an expensive and complicated special development in the present case that serves only a very small market segment and therefore, with some degree of probability, would not achieve the recognition accuracy of the known large conversion systems from Amazon, Google, Microsoft Azure or Apple, as far as general-language terms are concerned, which of course also have to be taken into account and correctly recognized, in addition to the chemical technical terms, in speech inputs. Rather, embodiments of the invention use the already very good recognition accuracy of the existing service providers for general-language terms and carry out a correction before outputting the recognized text. Over the course of the correction, the wrongly recognized words are replaced with

technical words on the basis of the association table, with the result that a corrected text is produced that is finally output. The highly specific technical vocabulary, which needs to be continuously updated on account of the dynamics of the field and the multiplicity of market participants, products and corresponding product names in order to keep the software suitable for practice, is therefore ultimately in an association table. This table can be kept up-to-date with very little effort. Modification of program source code, of statistical voice models, recompilation and/or retraining of machine learning programs is thus not required in accordance with embodiments of the invention; modification of or addition to a table is sufficient.

New technical words can be easily added by adding the new technical words, in each case together with one or more target vocabulary words recognized by mistake for this technical word, to the association table. From a technical point of view, the storage and updating of the technical words are thus completely decoupled from the actual voice recognition logic. This also has the advantage that dependence on one particular provider of voice recognition services is avoided. The field of voice recognition is still young and it is not yet foreseeable which of the multiplicity of parallel solutions are the best choice in the long term with regard to recognition accuracy and/or price. The tie to one specific voice-to-text conversion system results, according to embodiments of the invention, only from the received voice signal initially being sent to this conversion system and an (erroneous) text being received. Additionally, the association table contains erroneously recognized words from the target vocabulary that were (incorrectly) returned by this specific conversion system for a specific technical term. Both can easily be changed, however, by using a different voice-to-text conversion system to generate the (erroneous) text and, for this purpose, this other conversion system moreover being used to produce the association table afresh. Complex changes, for example to the logic of a syntax parser and/or a neural network, are not required.

The combination comprising the everyday-language voice-to-text conversion system according to embodiments of the invention can also be advantageous for field service employees in the chemical industry or in chemical production, since these employees often use a computer or at least a smartphone in the course of their business activity anyway and are distracted from the customer or their activity less by a voice input into correction software e.g. configured as an app or as a browser plug-in than by a text input using the keypad. These users can likewise be provided with access to and control of the functions of the laboratory device and/or the laboratory software module of the laboratory system by means of client software on the terminals of said users, said client software being interoperable with the supervisory software in order to forward voice signals from said users to the voice-to-text conversion system via the supervisory software.

A further advantage can be that, according to embodiments, the portable device merely picks up the voice signal, forwards it to the supervisory software and optionally receives and outputs a result of the performance of a function according to statements in the voice input. The actual voice-to-text conversion of the voice signal into a text, that is to say the most computing-intensive step by far, is carried out by the voice-to-text conversion system. The voice-to-text conversion system can be for example a server connected to the supervisory software via a network, for example the Internet. Hence, even a portable device with low processor power, for example a smartphone or a single-board computer, can be used for inputting long and complex voice inputs, and the resources of the computer on which the supervisory software is installed are also conserved.

According to embodiments, the supervisory software is in the form of a virtual laboratory assistant for the operation of the at least one laboratory device and the at least one laboratory software module.

This can be advantageous because the input of control commands by a user and the interaction between user and the laboratory devices or laboratory software modules is facilitated further. By way of example, the virtual laboratory assistant can implement one or more voice generators that each produce a computer-generated but naturally sounding voice and read aloud the results of the performance of a specific function by a laboratory device or a laboratory software module to the user in this natural voice. It is also possible for the virtual laboratory assistant to "listen" for a specific name, that is to say to examine a voice input or text generated therefrom for whether its name is mentioned therein and, if so, to perform specific functions itself or to have them performed by a target system. The laboratory worker can thus interact with the supervisory software and the virtual laboratory assistant implemented thereby in a similar manner to how he would with a human colleague.

According to embodiments, the portable device is configured to receive a voice signal from the user via the microphone and to forward the received voice signal to the supervisory software. The voice signal is forwarded in order to allow the voice signal to be converted into a text by the supervisory software or by a voice-to-text conversion system operatively connected to the supervisory software.

According to embodiments of the invention, the portable device further comprises a loudspeaker. The portable device is configured to respond to the sending of the voice signal by receiving a result of performance of a function from the supervisory software. Said function is performed in accordance with the text by the at least one laboratory device and/or by the at least one laboratory software module. The portable device is further configured to output the received result to the user via the loudspeaker.

By way of example, the received result can be text that is converted into an audio signal by means of text-to-voice

conversion software of the device. According to alternative embodiments, the supervisory software contains a text-to-voice conversion function, and the result is already sent to the portable device in the form of an electronic audio signal, so that the terminal, which has only low computing capabilities in some embodiments, no longer has to perform text-to-voice conversion.

The output of the result as an audible signal via the loudspeaker can be advantageous because the user is therefore not limited in the freedom of movement achieved by the voice-based input of commands. The user can thus move freely from any point in the laboratory that is within the detection area of the microphone and of audibility of the audible output from the loudspeaker and in that event can both deliver control commands and search requests by voice input and receive the results of the performance of these commands and/or information searches. This is useful within the context of laboratory work, in particular, since laboratory personnel frequently need to change between different devices and laboratory areas, for example in order to reload or configure machines, to supervise the progress of a work step, to release blocked components or transport boxes and the like.

According to some embodiments, the results of the software or hardware function performed by the laboratory software module or the laboratory device in accordance with the voice input are displayed to the user via a screen. This can take place in addition to or instead of the output via the loudspeaker. Specifically in the case of complex and extensive results, e.g. the documents ascertained in the course of a database or Internet query, the output on a screen can be advantageous, because a user may not be able to pick up and understand all the information of a long text if said text is output only via the loudspeaker.

According to embodiments, the portable device is located within the same room as the at least one laboratory device and/or in

the same room as a main control computer of a laboratory installation containing the at least one laboratory device.

This can be advantageous because most microphone types and in particular the microphone of the portable device are capable of recording voice inputs within a room and/or because the volume of most common loudspeakers, and in particular that of the loudspeaker of the portable device, is sufficient to be heard and understood by people in the same room.

According to some embodiments, the laboratory system comprises two or more of the portable devices having a microphone and having an optional loudspeaker that are described in the present case. These devices are preferably positioned with an even distribution in the laboratory room. This can be advantageous because it allows particularly good coverage both in terms of the receiving of voice inputs and in terms of the output of the results by loudspeaker to be achieved.

According to embodiments of the invention, the portable device is a single-board computer, in particular a Raspberry Pi computer.

This can be advantageous because such single-board computers are inexpensive components that are designed to be adapted and modified by the end user, e.g. by installing client software that is interoperable with freely stipulable server-end software, e.g. the supervisory software, via a network in order to allow the user to use the functionality of the supervisory software by voice input.

By way of example, the "Google Assistant SDK" permits integration of Google's voice recognition services into a terminal such as e.g. Raspberry Pi. Numerous video tutorials in this regard can be found on YouTube.

In accordance with embodiments of the invention, the portable device is not connected directly to a Google service or other

voice-to-text conversion service, however, but rather client software is merely installed that renders the portable device interoperable with the supervisory software that coordinates the data interchange with a network-connected voice-to-text conversion system and the correction of the text received from this conversion system.

For example, the software "Google Assistant on Raspberry Pi" can be installed on the Raspberry Pi and configured so that the voice signals received by the portable device are sent to the supervisory software. The address of the supervisory software is thus prescribed and stored in the portable device. This can be advantageous because a portable and very inexpensive terminal is provided for the purpose of simplified interaction with data-processing devices and services within a laboratory that can be configured such that it interoperates with any software applications, e.g. supervisory software implementing a virtual laboratory assistant.

Relocation of this coordination function to the supervisory software can be advantageous because Raspberry Pi computers have only low computing power and therefore the coordination of the conversion of voice signals into text and any subsequent text correction can be performed more quickly by other, more powerful devices.

According to embodiments of the invention, the technical-language terms are words from one of the following categories:

- names of chemical substances, in particular of dyes and paints; in particular the names relate to chemical names according to a chemical naming convention, e.g. according to the IUPAC nomenclature;
- physical, chemical, mechanical, optical or haptic properties of chemical substances;
- names of laboratory devices and chemical industry devices (e.g. trade names or own names that the user gives to the laboratory devices of a laboratory);
- names of laboratory consumables and laboratory equipment;

- trade names in the dye and paint realm.

According to embodiments of the invention, the technical-language words are words from the field of chemistry, in particular chemical industry, in particular the chemistry of dyes and paints.

According to embodiments of the invention, the target vocabulary consists of a set of general-language words.

According to other embodiments of the invention, the target vocabulary consists of a set of general-language words and words derived therefrom. These derived words can be dynamically produced concatenations of two or more general-language words, for example. In the German language, many words, in particular nouns, are formed by combination of multiple other nouns, for example. As such, e.g. the word "Schiffsschraube" [ship's screw] is so customary that it is normally present in most general-language dictionaries. A less commonly used term such as "Befestigungsschraube" [fixing screw] is absent from most general-language dictionaries, on the other hand. Some speech-to-text conversion systems can also recognize words such as "Befestigungsschraube" by means of heuristics and/or neural networks, however, provided that the individual word constituents "Befestigung" and "Schraube" are part of the target vocabulary. In this respect, the word "Befestigungsschraube" is then also part of the target vocabulary of this type of voice-to-text conversion system.

According to other embodiments of the invention, the target vocabulary consists of a set of general-language words complemented by words formed by combining recognized syllables. These voice-to-text conversion systems are thus more flexible in respect of which words can be recognized, since the recognition can take place - at least also - at the level of individual syllables, not just of individual words. However, syllable-based recognition is also particularly susceptible to error, since the risk of erroneous recognition of a word that

does not exist in a known vocabulary is particularly great. The finite nature of the set of supported or known syllables and the restriction of the set of combinable syllables by the typical word length mean that the set of target words generable on a syllable basis is also finite. Hence, even voice-to-text conversion systems that support syllable-based word generation have a finite target vocabulary despite their greater flexibility. Even if the flexibility of such systems means that they are theoretically capable of dynamically recognizing even many chemical terms that are not contained in a previously known dictionary, recognition accuracy is so low in practice that, with regard to practice, such systems also ultimately have a target vocabulary that does not contain or does not support these chemical terms.

In some embodiments of the invention, the target vocabulary consists of a set of general-language words complemented by words derived therefrom and complemented by words formed by combining recognized syllables. These conversion systems are also based on a target vocabulary that does not contain the technical words or cannot recognize them with sufficient accuracy in practical use, but instead recognizes other words, typically general-language words, incorrectly and converts them into text.

Hence, a multiplicity of different voice-to-text conversion systems already available today can be used for embodiments of the invention, even if these systems substantially "support" only everyday-language words (i.e. can correctly recognize them with sufficient accuracy and convert them into text).

According to embodiments of the invention, the computer system performing the text correction, that is to say e.g. the computer with the supervisory software or the correction computer, receives or calculates commonness statements for at least some of the words in the text produced from the voice signal by the voice-to-text conversion system. The commonness statements

indicate for each word in this text how frequently the occurrence of this word can be expected statistically.

Generation of the corrected text involves only words from the target vocabulary in the received text whose statistically expected frequency of occurrence in accordance with the received commonness statements is below a predefined threshold value being selectively replaced with technical-language words in accordance with the association table.

This can be advantageous because voice inputs by the user normally contain a mixture of general-language words and technical words. The case may thus also arise that the text received from the conversion system contains words from the target vocabulary that are associated with a technical word in the association table and that would normally be replaced. For example, the returned text could contain the expression "polymer innovation". Since this expression "polymer innovation" is associated with a technical word "polymerisation" in the association table, the expression would normally be replaced with "polymerisation" in the course of the text correction. If the expression "polymer innovation" has an associated commonness statement representing a high probability of occurrence, however, the correction software assumes on the basis of this frequency of occurrence that the expression "polymer innovation" is correct, even though it is assigned to a technical word in the association table, and consequently leaves the expression "polymer innovation" unchanged in the text. By way of example, a contextual analysis of the words within the sentence or within the whole voice input can reveal that the word "innovation" frequently occurs on its own in the text, e.g. because the text comes from a field employee outlining the advantages of a specific polymer product. In this context, the expression "polymer innovation" can also be a correctly recognized expression. In a context in which neither "polymer" nor "innovation" are mentioned on their own, the probability falls. Words also have probabilities of occurrence that are already

different per se regardless of context, said words being derivable e.g. from large bodies of text.

The replacing of words in accordance with the association table on the basis of probabilities of occurrence of the words in the received text can be advantageous, because in a few individual cases words from the target language that have a high probability of occurrence per se or within the context of the respective text are prevented from being incorrectly replaced with a technical word, and an error is prevented from being generated instead of corrected as a result of the replacement.

According to one embodiment, the frequencies of occurrence of the words of the text are calculated by the voice-to-text conversion system and returned to the supervisory software by the voice-to-text conversion system together with the text. By way of example, the voice-to-text conversion system can use Hidden Markov Models (HMMs) to calculate the probability of occurrence of a specific word within the context of a sentence. Additionally or alternatively, the voice-to-text conversion system can equate the frequency of occurrence of a word to the frequency of occurrence of the word in a large reference body. By way of example, all of the texts in a newspaper over several years or another large data record of texts can serve as reference body. The ratio of the counted number of words in the body to all of the words in the body is the frequency of occurrence of this word that is observed in this reference body. The commonness statements can be sent to the supervisory software by the voice-to-text conversion system together with the text.

According to a further embodiment, the frequencies of occurrence of the words of the text are calculated by the supervisory software or the correction software after receiving the text. As already described above, the probabilities of occurrence of the individual words or expressions can be calculated by means of HMMs by taking into consideration the textual context of a word or on the basis of the commonnesses of the word in a

reference body. The reference body used can be for example all of the texts transmitted from the voice-to-text conversion system to the supervisory software or correction software to date.

Hence, according to embodiments, the commonness statements are calculated (e.g. by the supervisory software or the correction software) by means of a Hidden Markov Model. By way of example, the expected frequency of occurrence, that is to say the probability of occurrence, can be calculated as the product of the probabilities of emission of the individual words of a word sequence as described e.g. in B. Cestnik "Estimating probabilities: A crucial task in machine learning" In Proceedings of the Ninth European Conference on Artificial Intelligence, pages 147–150, Stockholm, Sweden, 1990.

According to embodiments of the invention, the program performing the text correction receives not only the text but also part-of-speech tags (POS tags) - for at least some of the words in the text produced from the voice signal by the voice-to-text conversion system. The POS tags are received from the voice-to-text conversion system by the supervisory software directly or by the correction software indirectly via the supervisory software and contain at least tags for noun, adjective and verb. It is also possible for the POS tags to contain additional types of syntactic or semantic tags. The precise make-up of the POS tags taken into consideration can also be dependent on the respective language. The association table stores the technical-language words in combination with the POS tags thereof. Generation of the corrected text involves only words from the target vocabulary in the received text whose POS tags are concordant being replaced with technical-language words in accordance with the association table.

This can be advantageous because the accuracy of the text correction step is increased thereby. The POS tags in the association table can be assumed to be correct because the entries in the table are produced semiautomatically by virtue

of one or more speakers inputting a technical-language word or a technical-language expression into a microphone, the resultant audio signal being converted into an (erroneous) word or into an (erroneous) expression from the target vocabulary by the voice-to-text conversion system and this erroneous word or this erroneous expression being stored in the association table in combination with the technical-language expression. Since it is known what the technical-language word represents and whether it is a noun, verb or adjective, for example, the technical-language expression can also be stored in combination with the correct POS tag immediately when there is the opportunity for the table to be generated or updated. That is to say that if, although a specific word and a specific expression in the text need to be replaced with a technical-language word in accordance with the association table, the POS tags of the text to be replaced are not concordant with the POS tag of the technical-language words, this is an indication that the applicable words in the text might possibly be correct after all. The recognition rate of the POS tags is comparatively high, which means that this measure allows the quality of the correction step to be increased. By way of example, it may be that a technical-language word is e.g. the trade name "Platilon®". This denotes thermoplastic polyurethane films from the Covestro company. This technical word has an associated POS tag "Noun" in the table. The voice-to-text conversion system knows that it has often incorrectly converted the spoken word "Platilon" the target vocabulary word "platinum", and therefore the technical word "Platilon" has the associated word "platinum" from the target vocabulary in the association table. In a current voice input by a user, the word was used adjectivally, however: "Add a platinum- or zinc-based catalyst [...]". From the POS tag for "platinum" in the text returned by the conversion system, it can be recognized in the present case that the word "platinum" is correct in the present case and is not supposed to be replaced with "Platilon".

According to embodiments, the supervisory software is provided as a cloud service by a cloud computer system or an individual

server computer system. This cloud computer system or server system can be e.g. a system operated by the operator of the laboratory, e.g. a university or a company.

According to one embodiment, the supervisory software performs the text correction itself by means of or in interoperation with a program installed locally on the same computer as the supervisory software.

According to another embodiment, the text received from the voice-to-text conversion system is corrected by a different computer connected to the computer of the supervisory software via a network. The other computer can be e.g. a cloud system or an individual server that is e.g. likewise operated by the operator of the laboratory. The supervisory software sends the received text to the software and the computer performing the correction on the basis of the association table, and receives the corrected text from this software or this computer ("correction software" or "correction computer"). The network connecting the supervisory software to the remote correction software can be e.g. the Internet or the intranet of an organisation. This embodiment can be advantageous since it is possible to better separate the access rights to the functions and data of the supervisory software, on the one hand, and of the correction software, on the other hand. If the text correction is carried out on a separate correction computer or correction cloud system, a user can be selectively granted access to the correction computer or the correction cloud system in this case for the purpose of updating the table, without this also resulting in or requiring access being granted to sensitive data of the supervisory software, which can control e.g. sensitive functions of laboratory devices.

According to embodiments of the invention, coordination of the data interchange with the voice-to-text conversion system, the text correction and the forwarding of the corrected text to the implementation system are therefore performed completely by the supervisory software or are organized and coordinated thereby.

According to some embodiments of the method, the portable device is thus substantially a device having a microphone and an optional output interface for results of the implementation of the corrected text.

According to embodiments of the invention, the voice-to-text conversion system is implemented as a service that is provided to a multiplicity of terminals via the Internet. By way of example, the voice-to-text conversion system can be a cloud computer system with Google's cloud service "Speech-to-Text". This can be advantageous because there is a functionally powerful API client library therefor, e.g. for .NET.

The portable device can contain client software pre-configured for data interchange with the supervisory software. This means that the client software on the portable device is configured to send the voice signal to the supervisory software via a network, so that the supervisory software can prompt the conversion of the voice signal into text and the technical-language correction of the text and also the performance of a function in accordance with the corrected text. The result of the implementation of the corrected text can be received by the portable device in response to the sending of the voice signal and output via the loudspeaker.

According to embodiments of the invention, the words and expressions from the target language that are stored in the association table are erroneous text outputs from the voice-to-text conversion system that were generated on the basis of voice inputs of technical words by a multiplicity of different people.

According to embodiments of the invention, the method comprises steps for generating the association table. For each of a multiplicity of technical-language words, at least one reference voice signal, which selectively represents this technical-language word, is recorded. The reference voice signal comes from at least one speaker. For technical-language expressions too, at least one reference voice signal, which selectively

represents this technical-language expression, can be spoken by at least one speaker and recorded in each case. The further steps are substantially identical for words and expressions, which means that where a technical-language word is referred to below, a technical-language expression is included. Each of the recorded reference voice signals is input into the voice-to-text conversion system. The input can take place in particular via a network, e.g. the Internet. For each of the input reference voice signals, the device that input the reference signals receives at least one word from the target vocabulary that was produced from the input reference voice signal by the voice-to-text conversion system. This device can be e.g. any data processing system having a microphone and a connection to the voice-to-text conversion system. Preferably, the reference voice signals are input via a device that is as similar as possible to the portable device in terms of the type of its microphone and/or its positioning relative to sound sources, in order to ensure that the same errors are reproducibly generated. The at least one word (which can also be an expression) from the target vocabulary that is received for each of the technical-language words represents an incorrect conversion, since the target vocabulary of the voice-to-text conversion system does not support the technical-language words. Finally, the association table is generated as a table that associates with each of the technical-language words for which at least one reference voice signal was recorded the at least one word from the target vocabulary in text form that was returned for this technical-language word by the voice-to-text conversion system.

This can be advantageous because a table can be modified and added to very simply without having to change a source code, recompile a program or retrain a neural network. Even if another voice-to-text conversion system is used, only the applicable client interface needs to be adapted and the technical-language expressions of the table can be re-input by one or more speakers via a microphone and transmitted to the new voice-to-text conversion system. The incorrect words and expressions from the target language that are returned by this new system form the

basis for the new association table. It is therefore possible, without deep-rooted or complex changes and without retraining voice software, to functionally extend any everyday-language voice-to-text conversion systems such that spoken texts with technical-language words and expressions are also converted to text correctly.

The association table can be stored as a table of a relational database or as a tab-delimited text file or as another functionally comparable data structure, for example.

According to embodiments of the invention, multiple reference voice signals from each of different speakers are recorded for each of at least some of the technical-language words (or technical-language expressions). The multiple reference voice signals reproduce this technical-language word (or this technical-language expression). The association table associates multiple words (or expressions) from the target vocabulary in text form with each of at least some of the technical-language words (or expressions). The multiple words (or expressions) from the target vocabulary represent incorrect conversions that the voice-to-text conversion system has produced for the different speakers on the basis of their voice.

By way of example, a specific technical-language word such as **"1,2-methylenedioxybenzene" can be read aloud by 100 different** people and recorded using a microphone as a respective reference voice signal. Preferably, these people are people familiar with the pronunciation of chemical expressions. This means that there are then 100 reference voice signals available for this one substance name. Each of these 100 reference voice signals is sent to the voice-to-text conversion system, and in response 100 words or expressions from the target vocabulary are returned that all incorrectly reproduce the actual technical-language name. Often, the 100 returned words will be identical, but not always. Different people have different voices, i.e. the voice input differs in regard to emphasis, volume, pitch and enunciation. It is therefore possible for a specific voice-to-

text conversion system to return multiple different, incorrect words or expressions for a specific technical-language word (or a specific technical-language expression) that are all entered into the association table.

Taking account of the voice inputs of many different people to produce the association table can be advantageous because this takes better account of the variability of human voices and thus allows an improved error correction rate to be achieved.

According to embodiments of the invention, the at least one laboratory device is a multiplicity of laboratory devices. The laboratory devices are each selected from a group comprising:
- an analysis station designed to analyse chemical substances or substance mixtures; and/or
- a synthesis station designed to perform a synthesis of chemical substances or substance mixtures; and/or
- a preprocessing or post-processing station designed to purify, combine with other substances, dilute, concentrate or otherwise modify a chemical substance before or after an analysis or synthesis step such that a subsequent work or transportation step is possible.

According to embodiments of the invention, the at least one laboratory device is a multiplicity of laboratory devices that each serve as processing stations for a chemical substance. The laboratory devices and optionally also the at least one laboratory software module can be part of a laboratory installation that additionally also comprises a transportation unit. The transportation unit is designed to transport the substances used for a synthesis or analysis to the processing stations in order to allow each of the processing stations to subject the substances to at least one processing step.

According to embodiments of the invention, the laboratory system further comprises a main control computer of a laboratory installation comprising the at least one laboratory device. The main control computer contains control software configured to

orchestrate the processing steps and the transportation of the chemical substances by means of the laboratory devices of the laboratory installation on the basis of instructions in the form of a structured text.

According to embodiments of the invention, the supervisory software comprises an NLP (Natural Language Processing) processor or is interoperable with an NLP processor connected via a network. The feature of one software application being interoperable with another software application in this case means that the interfaces and routines of the two interoperable software applications are attuned and adapted to one another such that both are together able to interchange requests, control commands and data in a coordinated manner such that this coordinated interchange performs a specific software-based function and the result thereof is returned to the requesting software application. The supervisory software is configured to use the NLP processor to transform the corrected text into a structured text that can be interpreted by a target system. The target system is the at least one laboratory software module, and/or the at least one laboratory device and/or control software of a main control computer of a laboratory installation comprising the at least one laboratory device. The supervisory software is configured to receive the structured text formed from the corrected text by the NLP processor from the NLP processor and to input it into the target system. The input of the structured text into the target system prompts the latter to perform a laboratory-related software and/or hardware function.

By way of example, M. Hummel, D. Porcincula and E. Sapper in **European Coatings Journal (01.02.2019), in the article "NATURAL** LANGUAGE PROCESSING. A semantic framework for coatings science - robots reading recipes", describe conversion of natural-language text inputs into structured text by means of syntax parsing, POS tagging and other techniques.

By way of example, the target system can be the at least one laboratory device and a transportation unit, which are prompted by the input of the structured text to perform a multiplicity of processing steps and the transportation of the chemical substances between the laboratory devices in accordance with the statements contained in the structured text.

According to another example, the target system is control software of a laboratory installation and the input of the structured text prompts said laboratory installation to perform a software function in accordance with the statements contained in the structured text. The software function can be e.g. the calculation of specific concentrations or other parameters used in the course of the performance of specific analyses and/or syntheses defined in the text, e.g. in order to configure or calibrate a laboratory device as appropriate or to set pH values and viscosities.

According to another example, the target system is a chemical database of the laboratory installation that contains results of analyses and syntheses already performed by the installation. The input of the structured text prompts the latter to perform a database search for the statements and terms contained in the structured text. The search results can be returned to the user directly as result via the supervisory software or can contain as input for further data processing steps, e.g. for simulation and prediction of advantageous recipes on the basis of the substances searched for.

According to embodiments, the laboratory system contains a chemical installation for analysing and/or synthesizing chemical substances and/or an installation for producing substance mixtures, in particular dyes and paints. The installation also contains the main control computer with the control software. The at least one laboratory device and the at least one laboratory software module are part of the high-throughput environment installation and can be supervised and controlled by the supervisory software by means of the control software.

The installation is designed to interpret the corrected text as a specification of the synthesis or as a specification of the components of the substance mixture or as a specification of the analysis to be performed.

The installation can be a high-throughput environment installation (HTE installation), e.g. a high-throughput environment installation for analysing and manufacturing dyes and paints. By way of example, the HTE installation can be a system for automatically testing and automatically producing chemical products as described in WO 2017/072351 A2.

The output of the corrected text, or of a structured text into which the corrected text has been converted, to the control software of the installation causes the control software to control one or more laboratory devices and/or one or more laboratory software modules of the installation as specified in the corrected text. This can be very advantageous in particular within the context of a biological or chemical laboratory, since the voice input is processed such that it can be forwarded directly to a technical system and correctly interpreted by the latter without the user having to remove gloves, for example, for this purpose. By way of example, the laboratory device can be a device for determining the number of oils in a pigment or a device for determining the viscosity of a paint.

By way of example, the installation can be designed to automatically perform one or more of the following work steps fully automatically in reaction to an input of the corrected text, or of the structured text obtained therefrom, via a machine-to-machine interface:

- rheological analyses of substances and substance mixtures;
- measurement of the storage stability of substances and substance mixtures, in particular on the basis of inhomogeneities and inclination of liquid substance mixtures towards settling; for example these analyses can take place on the basis of optical measurements in cuvettes after sampling;

- pH value determination for substances and substance mixtures;
- foam tests for substances and substance mixtures, in particular measurement of defoaming action and measurement of foam degradation kinetics;
- viscosity measurements for substances and substance mixtures; the viscosity measurement can include an automatic dilution step, in particular for highly viscous substances and mixtures, since viscosity is more easily determinable in a dilute solution; the viscosity of the dilute solution is taken as a basis for calculating the viscosity of the original substance or substance mixture;
- measurement of the rub-out behaviour (rub-out test) of the substance or substance mixture, in particular of the finished product;
- measurement of colour values for substances and substance mixtures on the basis of for example a light scattering spectrophotometer (what is known as an L-A-B value), haze and gloss
- layer thickness measurement for substances and substance mixtures applied to a plane using different defined parameters (temperature, air humidity, surface condition of the plane, etc.)
- image analysis methods for images of substances and substance mixtures, in particular for characterizing substance surfaces, e.g. number, size and distribution of air bubbles or scratches in dyes and paints.

The substances and substance mixtures can be in particular substances and substance mixtures used for manufacturing dyes and paints. Additionally, the substances and substance mixtures can be the end products, e.g. dyes and paints in liquid and dried form, and also intermediate products and solvents used.

According to embodiments of the invention, the contact-free use comprises a conversion of the voice input into a natural-language text.

The at least one laboratory software module can be e.g. in the form of a chemical substance database designed to interpret the input text as a search input and to ascertain information pertaining to the search input in the database and to return said information to the supervisory software as result. The database can be in particular a database management system (DBMS), e.g. MySQL or PostgreSQL.

Additionally or alternatively, the laboratory system can contain a laboratory software module that is simulation software. The simulation software is designed to simulate properties of chemical products, in particular of dyes and paints, on the basis of a prescribed substance mixture specification. The simulation software is designed to interpret the input text as a specification of the product whose properties are supposed to be simulated.

Additionally or alternatively, the laboratory system can contain a laboratory software module that is in the form of control software of a laboratory installation containing the at least one laboratory device. The control software is installed on a main control computer. By way of example, this can be the control software already described for embodiments in the present case. The control software is designed to prompt the laboratory devices and a transportation unit of the laboratory installation to perform and orchestrate a multiplicity of processing steps and the transportation of the chemical substances between the laboratory devices in accordance with the statements contained in the input text. The laboratory installation can be in the form of an HTE installation for controlling chemical analyses and/or syntheses and/or the production of substance mixtures, in particular dyes and paints. The control software is designed to interpret the corrected text, or a structured text extracted therefrom, as a specification of an analysis or of the synthesis or of the components of the substance mixture.

Additionally or alternatively, the laboratory installation can contain a laboratory software module designed to perform simple

data processing steps for data interchanged between components of the laboratory system within the context of an analysis or synthesis. This can be for example the conversion, inspection and/or addition of control commands from the control software to the laboratory devices, storage, inspection or normalisation of measurement data or similar data processing steps.

The text input into the laboratory device or laboratory software module in each case can be the corrected text or a structured text that an NLP processor has generated from the corrected text.

According to embodiments, the supervisory software is configured to use at least some corrected texts, e.g. texts containing a specific keyword such as "Internet search", as input for an Internet search engine. The supervisory software receives the results of the search, e.g. by parsing a browser window, and forwards the results for output to a target system close to the user, for example to the portable device with the loudspeaker.

According to embodiments of the invention, the supervisory software contains a register having the accounts of a multiplicity of users registered for the supervisory software. The supervisory software contains a voice recognition function for recognizing each of the registered users on the basis of his or her voice. The supervisory software is designed to allow the user to use, in contact-free fashion by voice input into the microphone, only the laboratory device and/or the laboratory software module that said user is authorized to use.

This can be advantageous, since access control and control of the laboratory devices and laboratory software modules are seamlessly interwoven with one another by virtue of both being made dependent on the voice of a user. It is not necessary to remember or keep safe passwords or special access tokens.

According to embodiments of the invention, the supervisory software allows a user to select a laboratory device from a

multiplicity of laboratory devices by inputting key terms as part of the voice input, in particular laboratory device names and/or room names, and to selectively control the functions of said laboratory device by means of the voice input. By way of example, the supervisory software is configured to analyse the corrected text for predefined key terms. If a key term is recognized, the supervisory software forwards the corrected text as natural-language text or structured text to precisely this recognized laboratory device or the control software thereof. This can be advantageous because the same voice-based interface can be used to control a multiplicity of different laboratory devices.

According to embodiments of the invention, the supervisory software is configured to automatically convert the corrected text produced on the basis of the voice input of the user into a structure that can be correctly interpreted by the target system respectively intended as the target system for this text input. By way of example, the supervisory software dynamically recognizes that the user, by mentioning the name of a specific laboratory device or of a laboratory installation in the voice input, has selected it as a target system from a multiplicity of available target systems in order to perform a specific function. The control system has stored for each of the target systems a format that is needed as input format by the respective target system, and automatically converts the corrected text or the structured text obtained therefrom into the required format of the dynamically recognized target system. By way of example, a first laboratory device can require specific parameters in the form of an XML file as input. Another has an NLP processor and can use the corrected text directly as input. A further laboratory device requires specific parameter values or recipes in tabular form. This can be advantageous because the user can input a voice input in the normal syntax of natural-language sentences. This means that the user does not first of all need to carefully memorise the required syntax of the individual laboratory devices and speak to each individual device "differently". Specific adaptation of the language structure of

the user to the vocabulary or syntax of the respective laboratory devices is therefore not necessary. The user can enter their input in the language syntax with which he or she is familiar and that he or she would also use when speaking to colleagues. The adaptation to the specific requirements of the interfaces of the individual laboratory devices is performed by the supervisory software.

In a further aspect, the invention relates to a method for controlling a laboratory device and/or a laboratory software module. The method comprises:

- providing at least one laboratory device and at least one laboratory software module, wherein the at least one laboratory device is designed to analyse and/or synthesize a chemical substance, wherein the at least one laboratory software module is designed to process data obtained from the at least one laboratory device;
- providing a data processing device having supervisory software, wherein the supervisory software provides a user with an interface for using the at least one laboratory device and/or the at least one laboratory software module; and
- providing a portable device having a microphone, wherein the device is interoperably connected to the supervisory software via a network, wherein the device is designed to interoperate with the supervisory software in order to allow the user to use the at least one laboratory device and/or the at least one laboratory software module in contact-free fashion by means of voice input into the microphone;
- wherein according to the invention the supervisory software:
- receives from the portable device a voice signal that the microphone has picked up on the basis of the voice input, wherein the voice signal contains general-language and technical-language words spoken by the user;
- inputs the received voice signal into a voice-to-text conversion system, wherein the voice-to-text conversion system supports only the conversion of voice signals into a target vocabulary that does not contain the technical-language words;

- receives from the voice-to-text conversion system a text that was generated from the voice signal by the voice-to-text conversion system;
- generates a corrected text from the received text, wherein the corrected text is generated by the supervisory software alone or by the supervisory software by means of interpretation with text correction software to which the supervisory software is operatively connected, wherein the corrected text is generated by automatically replacing words and expressions from the target vocabulary in the received text with technical-language words in accordance with an association table (238) of words in text form, wherein the association table associates at least one word from the target vocabulary with each of a multiplicity of technical-language words, wherein the at least one word from the target vocabulary that is associated with a technical-language word is a word or expression that the voice-to-text conversion system incorrectly identifies when this technical-language word is input in the form of a voice signal; and
- uses the corrected text to prompt the at least one laboratory device and/or the at least one laboratory software module
- to perform the analysis, synthesis and/or software function in accordance with statements in the corrected text.

According to embodiments, the providing of the device involves placing the portable device within the same room as the at least one laboratory device and/or placing the portable device in the same room as a main control computer of a laboratory installation containing the at least one laboratory device.

A “structured text” is understood in the present case to mean a text, in particular an ASCII text, containing words and expressions having a specific meaning at predefined positions. A structured text can have e.g. the form of a comma-separated file, a table, an XML document or the like. A structured text can be interpreted and processed by machines and computers more easily than natural-language text.

A "natural-language text" is understood in the present case to mean a text, in particular an ASCII text, that is written in a language spoken by human beings and typically consists of whole sentences.

An "NLP processor" is a software program or software function capable of understanding "natural-language" texts, i.e. processing them such that the relevant information that the text contains can be extracted from the text and optionally transformed into other formats, e.g. a structured text format. An NLP tool is thus capable of processing texts consisting of whole sentences and of extracting information from a single sentence.

A "transportation unit" is understood in the present case to mean an automatic system comprising one or more components that is able to transport chemical substances in liquid and/or solid form and optionally also further objects such as e.g. consumables or containers from one processing station to the next. The transportation unit can be e.g. a robot arm, a set of robot arms, a conveyor belt, a set of conveyor belts or combinations of these. The transportation unit can be part of a high-throughput environment installation and can be controlled by control software. A processing unit can be a laboratory device for analysing or synthesizing chemical substances or a device for preprocessing and post-processing of these substances (dilution, concentration, coloration, mixing, etc.).

A "voice-to-text conversion system" is a data processing system that to convert voice signals from a human being into a text. The data processing system can e.g. consist of a combination of hardware and software and e.g. be in the form of a cloud computer system or server computer system that makes a voice-to-text conversion service available to one or more client devices via a network.

"Contact-free use" of a device is use that involves no manual interaction by a user with the device or a human-machine interface of this device. That is to say that it is "touch-free", "contactless" use.

A "single-board computer" is a computer system in which all of the electronic components needed for operation are combined on a single printed circuit board. Typically, the power supply unit is accommodated separately as a single component.

A "voice signal" is an electronic signal recorded by a microphone when a human being enters a voice input into the microphone.

A "virtual laboratory assistant" is software or a software routine operatively connected to one or more laboratory devices and/or software programs in a laboratory such that information from these laboratory devices and laboratory software programs can be received and commands for performing functions can be sent from the laboratory assistant to the laboratory devices and laboratory software programs. A laboratory assistant thus has an interface for data interchange with and for controlling one or more laboratory devices and laboratory software programs. The laboratory assistant moreover has an interface to a user and is configured to allow the user to use this interface for facilitated use, monitoring and/or control of the laboratory devices and laboratory software programs. By way of example, the interface to the user can be in the form of an audio interface or natural-language text interface.

Preferably, a "virtual laboratory assistant" contains functions to make the interaction between the virtual assistant and the human being as similar as possible to a human-to-human interaction. By way of example, the virtual laboratory assistant can have a software function for reading aloud text in a largely natural voice. The text read aloud can contain e.g. the results of performance of a function that are output via a loudspeaker of a portable device. Additionally or alternatively, the virtual laboratory assistant can be configured to search received voice

signals or texts generated therefrom for keywords and to take these keywords as a basis for calling specific hardware or software functions. By way of example, one of these keywords can be a name, e.g. an ordinary human first name, that the virtual laboratory assistant interprets as its own name and understands as a command directed at it to perform or call its specific function.

A "laboratory device" is understood in the present case to mean electronic devices used in a laboratory that are used for performing chemical method steps such as syntheses or analyses or other processing steps for preparing or finishing a substance for the next/previous processing step.

A "laboratory installation" is understood in the present case to mean a system consisting of multiple laboratory devices, a transportation unit and one or more software modules that is capable of controlling the laboratory devices and laboratory software modules jointly in an orchestrated manner in order to perform a chemical workflow automatically or semiautomatically. The workflow can be e.g. a synthesis workflow or an analysis workflow or a combination of both workflows.

A "laboratory software module" is understood in the present case to mean a software application, a submodule of a software application or a software routine configured to process data that a laboratory device delivers as measurement data or uses as input parameters. Preferably, a laboratory software module is a physical and/or functional part of a laboratory device or laboratory installation.

A "vocabulary" is understood in the present case to mean a linguistic area, that is to say a set of words that can be used by an entity, e.g. a voice-to-text conversion system.

A "word" is understood in the present case to mean a coherent sequence of characters that occurs within a specific vocabulary and is a separate linguistic unit. In natural language, a word

- in contrast to a sound or a syllable - has an independent meaning.

An "expression" is understood in the present case to mean a linguistic unit comprising two or more words.

A "technical-language word" or "technical word" is understood in the present case to mean a word from a technical-word vocabulary. A technical-language word is not part of the target vocabulary and is typically also not part of the general-language vocabulary.

The expression that a voice-to-text conversion system merely supports the conversion of voice signals into a target vocabulary means that words from another vocabulary either cannot be converted into text at all or are converted into text only with a very high error rate, the error rate being above an error rate limit value per word or expression to be converted that must be regarded as the maximum tolerable for a working conversion of voice into text. By way of example, this limit value for an error probability per word or expression of over 50% can preferably already be above 10%.

A POS tag (or part-of-speech tag) is understood in the present case to mean a special label associated with each word in a text body in order to indicate the part of speech and often also other grammatical categories such as tense, number (plural/singular), capitalisation, etc. that this word represents in its respective textual context. A set of all the POS tags used in a body is referred to as a tagset. Tagsets for different languages are typically different. Basic tagsets contain tags for the most common language components (e.g. N for noun, V for verb, A for adjective, etc.).

A "portable device" is understood in the present case to mean a portable, preferably battery-operated, data processing device that is freely positionable and that is preferably wirelessly connectable to a network, e.g. the Internet or the intranet of

an organisation. By way of example, what are known as "smart speakers" having a microphone and/or single-board systems such as Raspberry Pi computers are used as a "portable device". However, it is also possible for a user to use his or her smartphone as a portable device, the smartphone having a microphone and client software interoperable with the supervisory software.

Brief description of the drawings

The figures that follow explain embodiments of the invention in more detail in an exemplary manner:

Figure 1 shows a flowchart for a method for controlling laboratory devices and laboratory software modules;

Figure 2 shows a block diagram of a distributed system for voice-based control of laboratory devices and laboratory software modules;

Figure 3 shows a block diagram of an alternative distributed system for voice-based control of laboratory devices and laboratory software modules;

Figure 4 shows a block diagram of a further distributed system for voice-based control of laboratory devices and laboratory software modules.

Detailed description

Figure 1 shows a flowchart for a computer-implemented method for voice-based control of laboratory devices and laboratory software modules.

A first step 102 involves one or more laboratory devices and one or more laboratory software modules being provided.

The laboratory devices can be individual devices or can be processing units within a complex laboratory installation. The laboratory devices can each be configured and equipped to perform one or more work steps within the context of the analysis and/or synthesis of substances or substance mixtures or for the

preparation and finishing of substances and substance mixtures within complex analysis or synthesis workflows.

Similarly, the laboratory software modules can be individually installable software applications, e.g. can be simulation software that takes data obtained from the laboratory devices as a basis for making statements or predictions regarding the chemical, physical, haptic, optical or other properties thereof. They can also be a DBMS having a database, wherein the database has stored the results of the previous analyses and syntheses of the laboratory devices and can use the content thereof for example to perform database searches for substances (e.g. dyes and paints) that were already manufactured and the properties of which are known. The search query can be a search for all paints having a viscosity below a limit value specified in the search query, for example. The software modules can also be modules and functions of a larger software application, e.g. from control software of a complex laboratory installation.

A further step 104 involves a data processing device with supervisory software being provided. The supervisory software makes an interface for using the at least one laboratory device and/or the at least one laboratory software module available to one or more users. The data processing device having the supervisory software can be located in the same room or laboratory area as the laboratory device or the laboratory installation containing the laboratory device. The data processing device can be e.g. a desktop computer or a server. Preferably, however, the data processing device is arranged in another room, e.g. a computer centre of the organisation that operates the laboratory or in the computer centre of an external cloud memory provider. Access to this data processing device and the supervisory software e.g. for maintenance purposes can be effected for example from a computer within the laboratory area, however.

Step 106 involves a portable device with a microphone being provided and configured such that it is connected to and

interoperable with the supervisory software via a network, e.g. the Internet or the intranet of said organisation. The device is designed to interoperate with the supervisory software in order to allow the user to use the at least one laboratory device and/or the at least one laboratory software module in contact-free fashion by means of voice input into the microphone. The portable device is preferably provided such that the device is set up close to the work area of a laboratory worker from which this laboratory worker wishes to control the laboratory device or where the laboratory worker otherwise goes about his or her laboratory work. It is also possible for the device having the microphone to be positioned at a central point within the laboratory area from where voice inputs from all areas of the room or laboratory area can easily be received and recorded by the microphone in largely uniform fashion.

According to embodiments, the providing of the device involves placing the portable device, e.g. a single-board computer having a microphone, within the same room as the at least one laboratory device and/or placing the portable device in the same room as a main control computer of a laboratory installation containing the at least one laboratory device.

Said steps can be performed in any order. They allow contact-free use of one or more laboratory devices and associated laboratory software modules by voice input from any areas of a laboratory without this requiring gloves to be removed. The reason is that the supervisory software allows the voice signal recorded by the microphone to be converted by a voice-to-text conversion system into a natural-language text that is subsequently corrected by specific text correction steps such that the technical-language words, e.g. from the chemical industry or from specific subdivisions such as for example dye and paint manufacture, in the voice input are also correctly reproduced in the text.

The steps carried out by the supervisory software, the laboratory devices and laboratory software modules can vary

slightly in different embodiments of the laboratory system, and the laboratory system can contain further components, e.g. an external text correction system and/or an NLP processor for transforming the corrected natural-language text into structured text. In some embodiments, however, the laboratory installation itself contains such an NLP processor performing this transformation, so that the corrected natural-language text can be input directly into the control software of the laboratory installation.

Figure 2 shows a block diagram of a distributed system 200 for voice-based control of laboratory devices 252, 254 and laboratory software modules 248, 250. The system 200 comprises laboratory devices 252, 254 and laboratory software modules 248, 250, a control computer 213 having supervisory software and a portable device 212 having a microphone. Optionally, the system can contain further portable devices 212 having substantially the same design and function. Optionally, the system can also contain a main control computer having control software for controlling the laboratory devices. Optionally, the system 200 can also contain the correction software 225, which can be implemented as a function of the supervisory software or as an independent locally or remotely installed software application. Optionally, the system 200 can also contain the NLP processor 258. Optionally, the system 200 can also contain the voice-to-text conversion system 226.

The laboratory devices and laboratory software modules that the system 200 contains are controlled by a user 202, e.g. a laboratory worker, who is in physical proximity to a portable device 212 having a microphone 214, by voice input 204. By way of example, the user can input the command "Synthesize the paint called <PAINT_NAME> and determine the rheological properties of the paint after the synthesis" into the microphone. The voice signal 206 recorded by the microphone for the voice input is forwarded from the portable device 212 via a network 236, e.g. the Internet or an intranet, to the supervisory software 222 installed on a control computer 213. The latter forwards the

voice signal 206 via the network to a general-language voice-to-text conversion system 226, which converts the received voice signal 206 into a text 208, the words and expressions of which are taken exclusively from a general-language target vocabulary 234 that does not contain the technical-language words such as the name of the paint or the word "rheological". By way of example, the voice-to-text conversion system 226 can be in the form of a cloud computer system that makes the conversion available in the form of a software-based service, referred to in the present case as "voice recognition processor" 232, to multiple clients. The voice-to-text conversion system 226 can be e.g. a cloud computer system from Google that provides Google's Speech-to-Text cloud service via the Internet. In this case, the interface 224 is thus a cloud-based API from Google. The voice-to-text conversion system returns the recognized text 208 to the supervisory software 222.

In accordance with the embodiment depicted in figure 2, the supervisory software contains a correction function 225. This has access to an association table 238 in which a multiplicity of technical words and technical expressions each have one or more associated words or expressions from the target vocabulary.

In the association table 238, words in text form are associated with one another. To be more precise, the association table associates at least one word from the target vocabulary with each of a multiplicity of technical-language words or technical-language expressions. The at least one word from the target vocabulary that is associated with a technical-language word (or technical-language expression) is a word or an expression that the voice-to-text conversion system recognizes incorrectly (and has already recognized incorrectly earlier on during production of the table) when this technical-language word is input into the voice-to-text conversion system in the form of an audio signal.

Optionally, the technical expressions can also have associated POS tags that are optionally evaluated and taken into

consideration by the correction function 225 in the course of text correction. The correction function 225 can also be in the form of a separate correction software application 225 that is installed on the control computer 213 and with which the supervisory software 222 is interoperable.

The supervisory software 222 transfers the received text 208 to the correction function or correction software 225 and prompts the latter to correct the text 208 by using the association table 238. In the course of correction, wrongly recognized words and expressions from the target language are replaced with respective associated technical-language words and expressions in accordance with the table. A corrected text 210 is produced that is either transmitted from the supervisory software 222 directly to a specific target system, for example a chemical installation 244, or that is initially forwarded to an NLP processor 258 to begin with.

The NLP processor depicted in figure 2 is installed on the control computer 213. In accordance with alternative embodiments, as depicted in figure 3, for example, the NLP processor can also be made available as a service via a network, however. The NLP processor analyses the syntactic structure of the corrected text 210 in order to capture the semantic content of the corrected text and to extract relevant information therefrom and convert it into a structured text 211. The step of converting the corrected text 210 into a corrected structured text 211 can be advantageous because many laboratory systems and laboratory software modules available on the market today still cannot interpret natural-language text correctly. However, many target systems have an input interface for structured text, that is to say for example for tables or XML files having a specific prescribed structure. In other embodiments, the target system contains a separate NLP processor, so that the corrected text 210 in natural-language form can be input into the target system. In this case, the supervisory software sends the corrected text 210 directly to the target system.

The target system can be for example an individual laboratory device or a laboratory installation containing multiple laboratory devices. The laboratory installation 244 depicted in figure 2 can be a high-throughput environment (HTE) installation containing a multiplicity of laboratory devices 252, 254 and one or more laboratory software modules 250, 248.

By way of example, the laboratory devices 252, 254 can be analysis devices configured to perform various chemical analyses (for example viscosity, pH value, colour, surface structure, layer thickness). By way of example, the software module 250 can be a chemical database that interprets the input text 211 or 210 as a search query and performs an appropriate search within the chemical substance database. The laboratory software module 248 is control software that is installed on a main control computer 246 of the chemical installation 244 and that is configured to coordinate the work steps to be performed by the individual laboratory devices of the installation. By way of example, the control software 248 controls not only the analysis steps performed by the analysis devices but also the work of a transportation unit 256 that transports substances and intermediate products from one processing station to the next within the chemical installation 244.

The control of chemical installations by means of a voice input can be particularly advantageous because these installations are now capable of manufacturing a specific chemical product, for example a specific dye or a specific paint, largely automatically on the basis of a specific recipe. It is therefore possible to input a recipe for the manufacture of a specific chemical substance or substance mixture by voice input and thereby to prompt the chemical installation 244 to manufacture the applicable substance or substance mixture automatically. Similarly, it is possible to initialise applicable analyses of substances by voice input or to control the performance of said analyses, if need be to interrupt, modify or stop it.

The internal database 250 can be used not only for storing chemical substances and substance mixtures and the properties thereof but also for storing the applicable recipes. The database 250 can thus contain for example recipes for dyes and paints and also the starting materials therefor and also the respective physical chemical, optical and other properties thereof. Additionally, the database can store other relevant data, for example product data sheets from the manufacturers of the substances, safety data sheets, parameters for configuring individual modules of the HTE installation for analysing or synthesizing specific substances or products and the like. The HTE installation is designed to carry out analyses and syntheses on the basis of recipes and instructions that are input in text form.

In some embodiments, one or more laboratory devices of the chemical installation have a separate interface by means of which they can receive a natural-language or structured corrected text 210, 211 directly from the supervisory software. In some other embodiments, the laboratory devices of the chemical installation can receive the corrected text 210, 211 from the supervisory software 222 only indirectly via the control software 248.

According to embodiments, the voice input contains key terms on the basis of which the supervisory software 222 ascertains the number and identity of the respective required target systems. The corrected text is then sent from the supervisory software to each of the identified target systems in natural-language or structured form. By way of example, a user can specify the target device to which the supervisory software sends the corrected text by inputting a key term “TARGET SYSTEM” followed by the name of the respective target system (laboratory device or software module). Additionally or alternatively, the supervisory software can also look for key terms itself, however, and use these terms to autonomously ascertain a suitable target system. By way of example, the voice input can merely stipulate a specific type of synthesis, and the supervisory software

dynamically decides which of a multiplicity of laboratory devices usable for the synthesis is used for the requested synthesis. The decision can be made on the basis of the current capacity level, for example, so that a laboratory device that is currently not at capacity or is at low capacity is chosen.

Preferably, the results 242 of the performance of a specific hardware or software function are returned to the supervisory software 222 by the target system. The supervisory software can then return the result of the performance of the function to the user 202. Various channels are possible for this. By way of example, the user can be sent an e-mail, an SMS or a message in another format that contains the results of the performance of the function. In accordance with the embodiment depicted in figure 2, the results 242 are - at least also - (or exclusively) returned to the portable device 212 and output via the loudspeaker 218 thereof. This is particularly advantageous because the laboratory worker 202 a maximum freedom of movement both as regards the input of control commands, chemical recipes and search queries and as regards reception of the results of the performance of an applicable hardware or software function. By way of example, the user can be in a specific work area of a laboratory room and, in parallel with their manual activity, prompt the analysis of a specific substance by voice command. The result of the analysis is communicated to him or her audibly via the loudspeaker. It is thus not necessary for the user to interrupt their current manual activity in order to request the results. Instead, the user can literally hold a dialogue with the supervisory software and, for example after receiving the result that a specific synthesis has ended, also use voice input to initialise applicable analysis steps for the substance produced. The efficiency of laboratory work can therefore be drastically increased, since the user is thereby rendered able to work in parallel to an increased extent and for example to prompt and supervise the control of complex syntheses and analyses in parallel with other laboratory work.

Common activities within a laboratory that, in accordance with embodiments of the invention, are able to be controlled by voice input relate for example to the following activities and voice inputs indicated in exemplary fashion therefor:

- The laboratory worker started an analysis of a specific paint in regard to the rheological properties thereof the day before and now wants to query the result saved in the database of the HTE installation. Possible voice input: "*CONTROL COMPUTER, show me the results of the rheological analysis by the HTE installation in room 22 on 24 February 2019*"
- The laboratory worker wants to save costs and considers replacing a specific solvent <<S_EXPENSIVE>> with a cheaper one <<S_CHEAP>>. The name <<S_CHEAP>> is a trade name of the manufacturer. However, the laboratory worker is not certain whether the cheaper solvent is suitable for the paint that is supposed to be manufactured, and wants to see the product data sheet specifying further details relating to the chemical and physical properties of the cheap solvent. Possible voice input: "*CONTROL COMPUTER, show me the product data sheet for* <<S_CHEAP>>" or "*CONTROL COMPUTER, show me the product data sheet for* <<S_CHEAP>> *stored in the HTE database from room 22*".
- After looking over the product data sheet for the solvent <<S_CHEAP>>, the laboratory worker is of the opinion that the solvent can probably be used to manufacture the specific paint instead of the more expensive solvent. However, it must be assumed that the recipe needs to be adapted somewhat, since multiple parameters such as pH value, rheological properties, polarity and others differ from those of the more expensive solvent. Since these properties interact with one another, it is not possible for the laboratory worker to identify the necessary adaptations for the recipe on the basis of theoretical considerations. The performance of test series is work-intensive and takes time. However, the laboratory has software that can predict (simulate) the properties of a chemical product, for example dyes and paints, from a specific recipe. The simulation can be based e.g. on CNNs (convolutional neural networks). The laboratory worker wants to use this simulation software to simulate the probable properties of a paint, based on a known

recipe, in which the expensive solvent was replaced with the cheap one. Possible voice input: "*CONTROL COMPUTER, have the HTE simulation software calculate the properties of a paint with the following recipe: 70.2 g naphthenic oil, 4 g methyl n-amyl ketone, 1.5 g n-pentyl propionate, 1 g Ultrasorb, 50 g* <<S_CHEAP>>, […]".

– The simulation has shown that the cheap solvent is not suitable for manufacturing the paint. The laboratory worker now wants to search the Internet for other solvents that can replace the expensive solvent without adversely affecting the quality of the product, in order to reduce costs. Possible voice input: "*CONTROL COMPUTER, search the Internet for: <<high-viscosity solvents for paint manufacture>>*".

In accordance with embodiments of the invention, all of these inputs and commands can be sent to the respective executing systems without the user having to leave the laboratory room and/or remove gloves in order to do so.

The voice inputs indicated in exemplary fashion above contain for the most part both general-language and technical-language words and expressions. As such, for example the words and expressions "rheological", "*naphthenic oil*", "*methyl n-amyl ketone*", "*n-pentyl propionate*" are chemical terms and <<S_CHEAP>> is a trade name of a chemical product. These words and expressions are typically not included in the vocabulary supported by common general-language voice-to-text conversion systems ("target vocabulary"). The subsequent correction by the correction software ensures that the voice inputs are converted into text correctly despite the use of a general-language voice-to-text conversion system 226. The supervisory software performs a multiplicity of coordination and control activities for the management and processing of the voice signal and of the text generated therefrom, which differ slightly depending on the system architecture.

Figure 3 shows a block diagram of an alternative distributed system 300 for voice-based control of laboratory devices and

laboratory software modules. The system 300 can contain substantially the same components and functions as depicted in Figure 2. In contrast to the system depicted in Figure 2, the correction software 255 is not part of the supervisory software and is also not installed locally on the control computer 213 as a separate software application, but rather is provided as a cloud service by a cloud computer system 302 via the Internet. The supervisory software 222 is configured to use an appropriate interface 304 to correct the text 208 received from the voice-to-text conversion system by means of the association table - which is now stored on the cloud computer system 302 - and to receive the corrected text 210.

Figure 4 shows a block diagram of an alternative distributed system 400 for voice-based control of laboratory devices and laboratory software modules. The data interchange for controlling the individual laboratory devices 406-414 of the HTE installation 244 is illustrated in greater depth of detail in Figure 4.

The laboratory comprises a laboratory area 404 in which various stand-alone laboratory devices 416, e.g. a centrifuge, and an HTE installation 418.

The HTE installation contains a multiplicity of modules and hardware units 406-414 that are managed and controlled by control software on a main control computer 246. The control software of this embodiment serves as a central interface for monitoring and controlling the devices that the HTE installation contains from the outside. The supervisory software 222 on the control computer 213 has access to the control software and is configured to send the corrected text 210, 211 in natural-language or structured form as an input to the control software and optionally also to further target systems, e.g. the laboratory device 416 and/or an Internet search engine 402. A corrected text 210, 211 is generated from a voice input 204 from a user 202 as already described in accordance with embodiments of the invention.

The supervisory software 222 can be implemented as a "virtual laboratory assistant" 223. The virtual laboratory assistant can listen for a name such as "CONTROL COMPUTER", "LUISA" or "EVA", for example. The supervisory software is configured to search the corrected text 210 for keywords and to take these keywords as a basis for calling specific hardware or software functions of a target system. By way of example, the supervisory software searches the text 210 for a keyword such as e.g. "CONTROL COMPUTER" or "EVA". If the corrected text contains this keyword, the virtual laboratory assistant 223 is prompted to analyse the corrected text further for whether the corrected text contains commands for performing a hardware or software function and, if so, which hardware or software is supposed to execute these commands under the control of the supervisory software or the laboratory assistant. By way of example, the corrected text can contain names of devices or laboratory rooms that specify the device and software to which the command is supposed to be forwarded.

The words "CONTROL COMPUTER" or other names of the virtual assistant in the voice input can thus be used in the chemical laboratory field analogously to the names "Siri" and "Alexa" for the known virtual assistants for "everyday problems", in order to allow more efficient and safe control of hardware and software functions.

In one possible implementation example, the result of the evaluation of the corrected text 210 by the virtual laboratory assistant is that an Internet search engine 402 is supposed to look for a specific substance specified as a technical-language word or expression in the corrected text 210. The corrected text or specific parts thereof are input into the search engine by the virtual assistant via the Internet. The results 424 of the Internet search are returned to the supervisory software or the assistant, which forwards them to a suitable output device close to the user 202, for example the portable device 212 having the microphone and a loudspeaker 214. Preferably, they are forwarded

such that the virtual laboratory assistant, that is to say the supervisory software, reads the results 424 aloud to the user in a naturally sounding voice via the loudspeaker 214.

In a further possible implementation example, the result of the evaluation of the corrected text 210 by the virtual laboratory assistant is that the stand-alone laboratory device 416, a centrifuge, is supposed to pelletise a specific substance at a specific speed. The name of the centrifuge and the substance are specified in the corrected text 210 as a technical-language word or expression, which is adequate, since the centrifuge automatically reads the centrifugation parameters to be used, such as duration and number of revolutions, from an internal database on the basis of the substance name. The corrected text or specific parts thereof are sent to the centrifuge 416 by the virtual assistant via the Internet. The centrifuge starts a centrifugation program associated with the substance and returns a message about the successful or unsuccessful centrifugation as a text message 422. The result 422 is returned to the assistant 223, which outputs it via the loudspeaker 214 and optionally also via further output interfaces, e.g. a screen, as described for the results 424.

In a further possible implementation example, the result of the evaluation of the corrected text 210 by the virtual laboratory assistant is that the HTE installation 244 is supposed to synthesize a specific paint. The components of the paint are likewise specified in the corrected text and consist of a mixture of trade names of chemical products and IUPAC substance names. The HTE installation receives the corrected text 210 and autonomously decides to perform the synthesis in the synthesis unit 414. A message about the successful synthesis or an error message is returned as result 426 from the synthesis unit 414 to the control software of the HTE installation, and the control software in turn returns the result 426 to the supervisory software or the virtual laboratory assistant, which forwards it to a suitable output device, for example terminal 312, which outputs these results 426 via the loudspeaker 214 and optionally

also via further output interfaces, e.g. a screen, as described for the results 424.

The software and/or the hardware to which the corrected text 210, 211 is output is preferably software and hardware within a laboratory 404. However, it is possible for the text or parts thereof to be additionally also sent to target systems outside the laboratory, the results of which are designed or suitable for use for a chemical analysis or synthesis.

The voice control of laboratory devices and laboratory software modules associated therewith can be used to search for and output results from analyses and syntheses already performed in the laboratory, laboratory protocols and product data sheets in applicable databases of the laboratory and to perform additional searches of public or proprietary databases also accessible on the Internet and via the Internet under voice control. Voice commands containing specific trade names of chemicals or laboratory devices or of laboratory consumables and/or names and adjectives from chemical technical language are also converted into text correctly and can therefore be interpreted correctly by the target system. In accordance with embodiments of the invention, largely voice-controlled, highly integrated operation of a chemical or biological laboratory or of a laboratory HTE installation is therefore made possible.

The hardware (smart speakers) of known voice-to-text cloud service providers pursues the aim of directly actuating and using the services developed by the cloud provider itself. Use in the technical vocabulary field is not developed, or is developed to only a very small extent, at present. All of the system architectures 200, 300, 400 shown in the present case allow the use of existing voice-to-text APIs of various cloud providers by means of separate, cloud-provider-independent hardware in order to allow subject-specific voice recognition and control, based thereon, of laboratory devices and electronic search services in a laboratory.

Within the context of the chemical synthesis of dyes and paints, the efficient obtaining of information regarding chemical substances and voice-based control of laboratory devices and HTE installations is particularly advantageous because a large number of starting materials is required for manufacturing dyes and paints, the properties thereof interacting with one another in a complex manner and greatly influencing the properties of the product. A large number of analyses, control steps and test series therefore arise within the context of the manufacture of dyes and paints. Dyes and paints are highly complex mixtures of up to 20 raw materials and more, for example solvents, resins, hardeners, pigments, fillers and numerous additives (dispersants, wetting agents, adhesion promoters, defoaming agents, biocides, flame retardants, among others). Efficient acquisition of information regarding the individual components and regarding the actuation of applicable analysis and synthesis installations can considerably speed up the manufacturing process and quality assurance for the products.

List of reference numbers

102-106 Steps
200 Distributed system
202 User
204 Voice input
206 Voice signal
208 Recognized text
210 Corrected text (natural-language)
211 Corrected text (structured text)
212 Portable device
213 Control computer
214 Microphone
218 Loudspeaker
222 Supervisory software
223 Virtual laboratory assistant
224 Voice-to-text interface (client end)
224′ Voice-to-text interface (server end)
225 Correction software
226 Voice-to-text conversion system/cloud system
232 Voice recognition processor
234 Target vocabulary
236 Network
238 Association table
242 Result of the implementation of the corrected text
246 Main control computer
248 Control software
250 Chemical database (DBMS)
252 Analysis device
254 Analysis device
256 Transportation unit
300 Distributed system
302 Server with text correction service
304 Correction service interface (client end)
304′ Correction service interface (server end)
308 NLP interface
310 Laboratory installation control interface
400 Distributed system

402 Internet search engine
404 Laboratory area/laboratory room
406 Analysis device
408 Analysis device
410 Mixer
412 Synthesis unit
414 Synthesis unit
414 Control computer
416 Stand-alone laboratory device
422 Result of the implementation of the corrected text (text form)
424 Result of the implementation of the corrected text (text form)
426 Result of the implementation of the corrected text (text form)

Patentkrav

1. Laboratoriesystem, indeholdende:
- i det mindste et laboratorieapparat (252, 254, 406, 408, 412, 414, 416), der er udformet til analyse og/eller syntese af en kemisk substans,
- i det mindste et laboratorie-softwaremodul (248), som er udformet til behandling af data, der er blevet udvundet af det i det mindste ene laboratorieapparat;
- et databehandlingsapparat (213) med en kontrolsoftware (222), der tilvejebringer en grænseflade til betjening af det i det mindste ene laboratorieapparat og/eller det i det mindste ene laboratorie-softwaremodul; og
- et portabelt apparat (212) med mikrofon (214), hvor apparatet via et netværk (236) er interoperabelt forbundet med kontrolsoftwaren, hvor apparatet er udformet til i interoperation med kontrolsoftwaren for en bruger (202) at muliggøre en indgrebsfri betjening af det i det mindste ene laboratorieapparat og/eller det i det mindste ene laboratorie-softwaremodul gennem taleinput (204) i mikrofonen;
kendetegnet ved, at kontrolsoftwaren er konfigureret til:
- modtagelse fra det portable apparat af et talesignal (206), som mikrofonen på basis af taleinputtet har optaget, hvor talesignalet indeholder almensproglige og fagsproglige ord, der er talt af brugeren;
- input af det modtagne talesignal i et tale-til-tekst-konverteringssystem, hvor tale-til-tekst-konverteringssystemet kun understøtter konverteringen af talesignaler til et målvokabular (234), som ikke indeholder de fagsproglige ord;
- modtagelse fra tale-til-tekst-konverteringssystemet af en tekst (208), som er blevet genereret af tale-til-tekst-konverteringssystemet ud fra talesignalet;
- generering af en korrigeret tekst (210) ud fra den modtagne tekst, hvor den korrigerede tekst genereres af kontrolsoftwaren alene eller af kontrolsoftwaren i interpretation med en tekstkorrektursoftware, med hvilken kontrolsoftwaren er operativt forbundet, hvor den korrigerede tekst genereres ved

automatisk erstatning af ord og udtryk fra målvokabularet i den modtagne tekst med fagsproglige ord i henhold til en tilordningstabel (238) af ord i tekstform, hvor tilordningstabellen til hvert af et multiplum af fagsproglige ord tilordner i det mindste et ord fra målvokabularet, hvor det til et fagsprogligt ord tilordnede i det mindste ene ord fra målvokabularet er et ord eller et udtryk, som tale-til-tekst-konverteringssystemet ukorrekt genkender, når dette fagsproglige ord indlæses i form af et talesignal; og
- anvendelse af den korrigerede tekst til at foranledige det i det mindste ene laboratorieapparat og/eller det i det mindste ene laboratorie-softwaremodul til at udføre analysen, syntesen og/eller softwarefunktionen ifølge oplysningerne i den korrigerede tekst.

2. Laboratoriesystem ifølge krav 1, hvor kontrolsoftwaren er udformet som virtuel laboratorieassistent til driften af det i det mindste ene laboratorieapparat og det i det mindste ene laboratorie-softwaremodul.

3. Laboratoriesystem ifølge et af de foregående krav, hvor det portable apparat er konfigureret til:
- modtagelse af et talesignal (206) fra brugeren via mikrofonen;
- videreledning af det modtagne talesignal til kontrolsoftwaren med henblik på konvertering af talesignalet til en tekst (208) ved hjælp af kontrolsoftwaren eller ved hjælp af et med denne operativt forbundet tale-til-tekst-konverteringssystem (226).

4. Laboratoriesystem ifølge krav 3, hvor det portable apparat endvidere omfatter en højttaler (218), hvor det portable apparat er konfigureret til:
- som svar på afsendelsen af talesignalet modtagelse fra kontrolsoftwaren af et resultat (242) af en udførelse af en funktion, hvor funktionen blev gennemført i henhold til teksten af det i det mindste ene laboratorieapparat og/eller af det i det mindste ene laboratorie-softwaremodul; og
- output af resultatet til brugeren via højttaleren.

5. Laboratoriesystem ifølge et af de foregående krav, hvor det portable apparat befinder sig inde i det samme rum (404) som det i det mindste ene laboratorieapparat og/eller i det samme rum som en hovedstyringscomputer (246) for et laboratorieanlæg, som indeholder det i det mindste ene laboratorieapparat.

6. Laboratoriesystem ifølge et af de foregående krav, hvor det portable apparat er en enkeltkortscomputer, især en Raspberry Pi.

7. Laboratoriesystem ifølge et af de foregående krav, hvor det ved de fagsproglige ord drejer sig om ord fra en af de følgende kategorier:
- navne på kemiske substanser, især på farver og lakker;
- fysiske, kemiske, mekaniske, optiske eller haptiske egenskaber af kemiske substanser;
- navne på laboratorieapparater og apparater inden for den kemiske industri;
- navne på laboratorieforbrugsmateriale og laboratorieartikler;
- handelsnavne inden for farve- og lakområdet.

8. Laboratoriesystem ifølge et af de foregående krav, hvor de i tilordningstabellen lagrede ord og udtryk fra målsproget udgør ukorrekte tekstoutputs fra tale-til-tekst-konverteringssystemet, som blev genereret på basis af taleinputs af fagord af et multiplum af forskellige personer.

9. Laboratoriesystem ifølge et af de foregående krav, hvor det i det mindste ene laboratorieapparat er et multiplum af laboratorieapparater, hvor laboratorieapparaterne hver især er udvalgt fra en gruppe omfattende:
- en analysestation (406, 408) der er udformet til at analysere kemiske substanser eller substansblandinger; og/eller
- en syntesestation (412, 414) der er udformet til at gennemføre en syntese af kemiske substanser eller substansblandinger; og/eller
- en før- eller efterbearbejdningsstation (410), der er udformet til at modificere en kemisk substans før eller efter et

analyse- eller syntesetrin sådan, at et efterfølgende arbejds- eller transporttrin er muligt.

10. Laboratoriesystem ifølge et af de foregående krav, hvor det i det mindste ene laboratorieapparat er et multiplum af laboratorieapparater, som hver især tjener som bearbejdningsstationer for en kemisk substans, endvidere omfattende:
- en transportenhed (256), der er udformet til at transportere de til en syntese eller analyse anvendte substanser til bearbejdningsstationerne, for hver gang at gøre det muligt for bearbejdningsstationerne at underkaste substanserne i det mindste et bearbejdningstrin;
- en hovedstyringscomputer for et laboratorieanlæg (244), som indeholder multiplummet af laboratorieapparater, hvor hovedstyringscomputeren indeholder en styresoftware, der er konfigureret til at orkestrere bearbejdningstrinene og transporten af de kemiske substanser baseret på instruktioner i form af en struktureret tekst.

11. Laboratoriesystem ifølge et af de foregående krav, hvor kontrolsoftwaren omfatter en NLP-processor (258) eller er interoperabel med en NLP-processor, og hvor kontrolsoftwaren er konfigureret til:
- anvendelse af NLP-processoren til at transformere den korrigerede tekst til en struktureret tekst (211), som kan interpreteres af et målsystem, hvor målsystemet omfatter det i det mindste ene laboratorie-softwaremodul, det i det mindste ene laboratorieapparat og/eller en styresoftware til en hovedstyringscomputer for et laboratorieanlæg, som omfatter det i det mindste ene laboratorieapparat; og
- input af den strukturerede tekst i målsystemet for at foranledige dette til at udføre en laboratorierelateret software- og/eller hardwarefunktion.

12. Laboratoriesystem ifølge et af de foregående krav, hvor den indgrebsfrie betjening omfatter en konvertering af taleinputtet til en tekst (210, 211),

- hvor det i det mindste ene laboratorie-softwaremodul er en kemisk substansdatabase, der er udformet til at interpretere den indlæste tekst som søgeinput og fremskaffe informationer om søgeinputtet i databasen og levere dem tilbage til kontrolsoftwaren som resultat; og/eller
- hvor det i det mindste ene laboratorie-softwaremodul er en simulationssoftware, der er udformet til at simulere egenskaber af kemiske produkter, især af lakker og farver, baseret på en foruddefineret substansblandingsspecifikation, hvor simulationssoftwaren er udformet til at interpretere den indlæste tekst som specifikation af det produkt, hvis egenskaber skal simuleres;
- hvor det i det mindste ene laboratorie-softwaremodul er en styresoftware (248) til en hovedstyringscomputer for et laboratorieanlæg (244), som indeholder det i det mindste ene laboratorieapparat, hvor styresoftwaren er udformet til at foranledige det i det mindste ene laboratorieapparat og en transportenhed til at gennemføre et multiplum af bearbejdningstrin og transporten af de kemiske substanser mellem laboratorieapparaterne svarende til de i den indlæste tekst indeholdte oplysninger.

13. Laboratoriesystem ifølge et af de foregående krav, hvor kontrolsoftwaren indeholder et register med accounts for et multiplum af brugere, der er registreret i kontrolsoftwaren, hvor kontrolsoftwaren omfatter en stemmegenkendelsesfunktion til genkendelse af hver af de registrerede brugere på grundlag af dennes stemme, hvor kontrolsoftwaren er udformet til for brugeren gennem taleinput i mikrofonen at muliggøre den indgrebsfrie betjening af kun det laboratorieapparat og/eller det laboratorie-softwaremodul, til hvis betjening denne bruger er berettiget.

14. Fremgangsmåde til styring af et laboratorieapparat og/eller et laboratorie-softwaremodul, omfattende:
- tilvejebringelse af i det mindste et laboratorieapparat (252, 254, 406, 408, 412, 414, 416) og i det mindste et laboratorie-softwaremodul (248), hvor det i det mindste ene

laboratorieapparat er udformet til analyse og/eller syntese af en kemisk substans, hvor det i det mindste ene laboratorie-softwaremodul er et laboratorie-softwaremodul til behandling af data, der er blevet udvundet af det i det mindste ene laboratorieapparat (252, 254, 406, 408, 412, 414, 416);

- tilvejebringelse af et databehandlingsapparat (213) med en kontrolsoftware (222), hvor kontrolsoftwaren for en bruger tilvejebringer en grænseflade til betjening af det i det mindste ene laboratorieapparat og/eller det i det mindste ene laboratorie-softwaremodul; og

- tilvejebringelse af et portabelt apparat (212) med mikrofon (214), hvor apparatet via et netværk (236) er interoperabelt forbundet med kontrolsoftwaren, hvor apparatet er udformet til i interoperation med kontrolsoftwaren gennem taleinput i mikrofonen at muliggøre for brugeren en indgrebsfri betjening af det i det mindste ene laboratorieapparat og/eller det i det mindste ene laboratorie-softwaremodul;

kendetegnet ved, at kontrolsoftwaren gennemfører:

- modtagelse fra det portable apparat af et talesignal (206), som mikrofonen på basis af taleinputtet har optaget, hvor talesignalet indeholder almensproglige og fagsproglige ord, der er talt af brugeren;

- input af det modtagne talesignal i et tale-til-tekst-konverteringssystem, hvor tale-til-tekst-konverteringssystemet kun understøtter konverteringen af talesignaler til et målvokabular (234), som ikke indeholder de fagsproglige ord;

- modtagelse fra tale-til-tekst-konverteringssystemet af en tekst (208), som er blevet genereret af tale-til-tekst-konverteringssystemet ud fra talesignalet;

- generering af en korrigeret tekst (210) ud fra den modtagne tekst, hvor den korrigerede tekst genereres af kontrolsoftwaren alene eller af kontrolsoftware i interpretation med en tekstkorrektursoftware, med hvilken kontrolsoftwaren er operativt forbundet, hvor den korrigerede tekst genereres ved automatisk erstatning af ord og udtryk fra målvokabularet i den modtagne tekst med fagsproglige ord i henhold til en tilordningstabel (238) af ord i tekstform, hvor

tilordningstabellen til hvert af et multiplum af fagsproglige ord tilordner i det mindste et ord fra målvokabularet, hvor det til et fagsprogligt ord tilordnede i det mindste ene ord fra målvokabularet er et ord eller et udtryk, som tale-til-tekst-konverteringssystemet ukorrekt genkender, når dette fagsproglige ord indlæses i form af et talesignal; og

- anvendelse af den korrigerede tekst til at foranledige det i det mindste ene laboratorieapparat og/eller det i det mindste ene laboratorie-softwaremodul til at udføre analysen, syntesen og/eller softwarefunktionen ifølge oplysningerne i den korrigerede tekst.

15. Fremgangsmåde ifølge krav 14, hvor tilvejebringelsen af apparatet omfatter en placering af apparatet inde i det samme rum (404) som det i det mindste ene laboratorieapparat og/eller i det samme rum som en hovedstyringscomputer for et laboratorieanlæg, som indeholder det i det mindste ene laboratorieapparat.

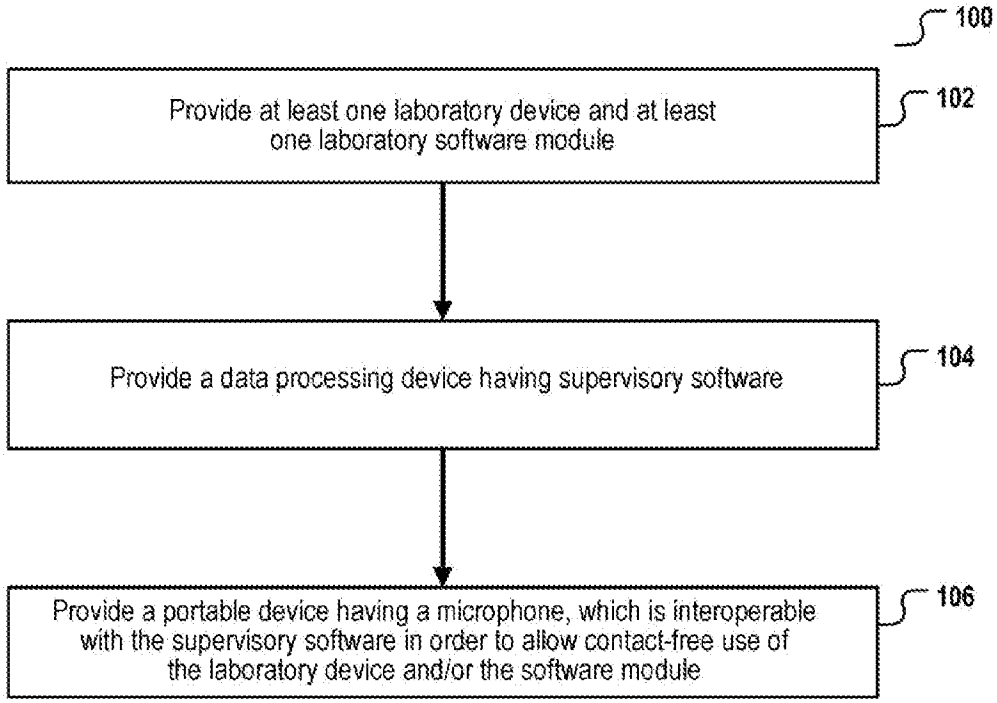
100
Provide at least one laboratory device and at least one laboratory software module
102
Provide a data processing device having supervisory software
104
Provide a portable device having a microphone, which is interoperable with the supervisory software in order to allow contact-free use of the laboratory device and/or the software module
106

Fig. 1

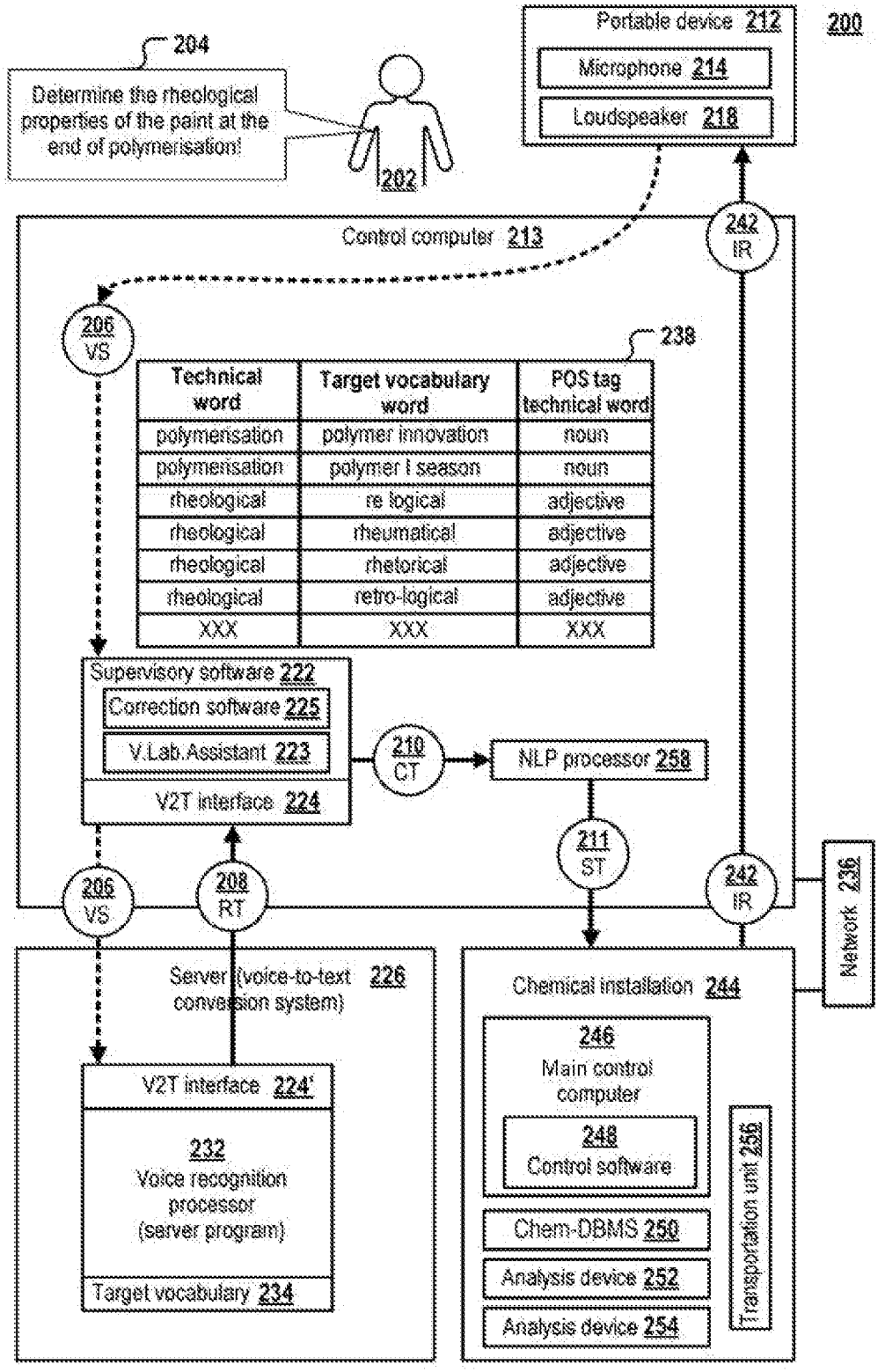
200
Portable device 212
Microphone 214
Loudspeaker 218
204
Determine the rheological properties of the paint at the end of polymerisation!
202
Control computer 213
242 IR
206 VS
238
Technical word | Target vocabulary word | POS tag technical word
polymerisation | polymer innovation | noun
polymerisation | polymer I season | noun
rheological | re logical | adjective
rheological | rheumatical | adjective
rheological | rhetorical | adjective
rheological | retro-logical | adjective
XXX | XXX | XXX
Supervisory software 222
Correction software 225
V.Lab.Assistant 223
V2T interface 224
210 CT
NLP processor 258
211 ST
206 VS
208 RT
242 IR
Network 236
Server (voice-to-text conversion system) 226
V2T interface 224'
232 Voice recognition processor (server program)
Target vocabulary 234
Chemical installation 244
246 Main control computer
248 Control software
Chem-DBMS 250
Analysis device 252
Analysis device 254
Transportation unit 256

Fig. 2

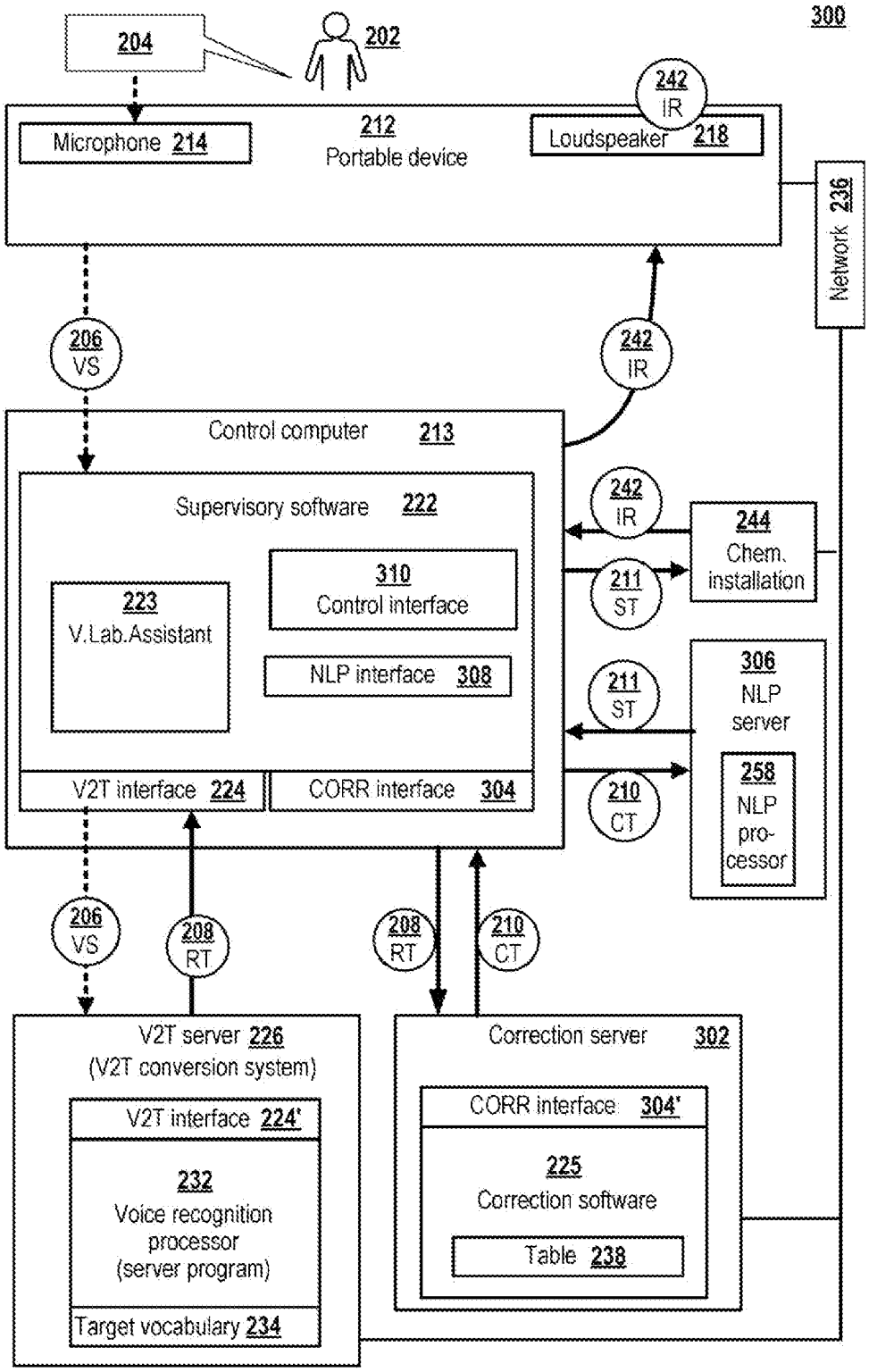
300
204
202
242
IR
Microphone 214
212
Portable device
Loudspeaker 218
Network 236
206
VS
242
IR
Control computer 213
Supervisory software 222
242
IR
244
Chem.
installation
310
Control interface
223
V.Lab.Assistant
211
ST
NLP interface 308
306
NLP
server
211
ST
258
NLP
pro-
cessor
V2T interface 224
CORR interface 304
210
CT
206
VS
208
RT
208
RT
210
CT
V2T server 226
(V2T conversion system)
Correction server 302
V2T interface 224'
CORR interface 304'
232
Voice recognition
processor
(server program)
225
Correction software
Table 238
Target vocabulary 234

Fig. 3

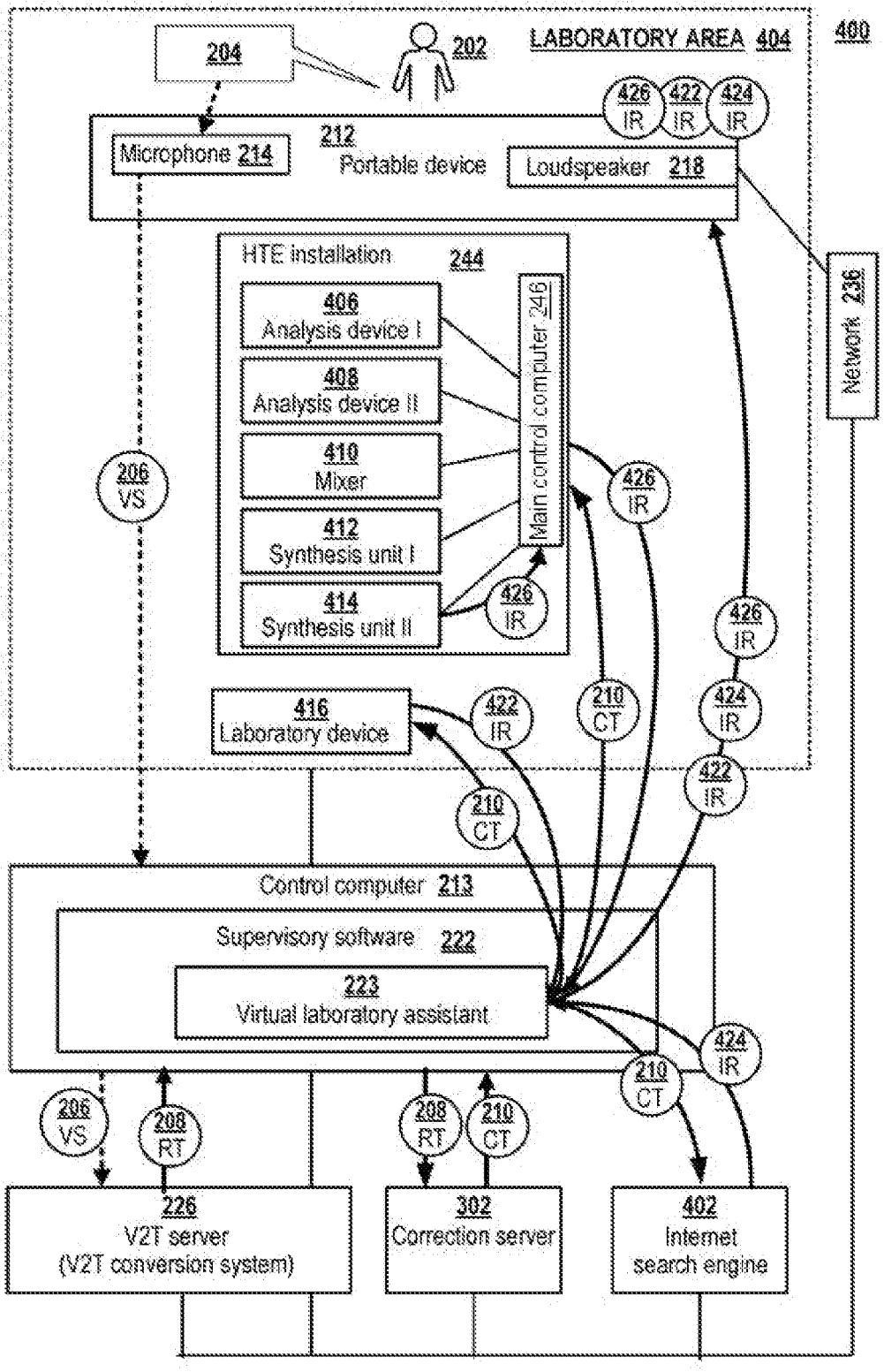
400
LABORATORY AREA 404
204
202
426 IR
422 IR
424 IR
212
Portable device
Microphone 214
Loudspeaker 218
HTE installation 244
406 Analysis device I
408 Analysis device II
410 Mixer
412 Synthesis unit I
414 Synthesis unit II
Main control computer 246
Network 236
206 VS
426 IR
426 IR
426 IR
416 Laboratory device
422 IR
210 CT
424 IR
422 IR
210 CT
Control computer 213
Supervisory software 222
223 Virtual laboratory assistant
424 IR
210 CT
206 VS
208 RT
208 RT
210 CT
226 V2T server (V2T conversion system)
302 Correction server
402 Internet search engine

Fig. 4