

INTELLIGENT SCORING METHOD AND SYSTEM FOR TEXT OBJECTIVE QUESTION

Field of the Invention

The present invention relates to the field of information processing technologies, and specifically relates to an intelligent scoring method and system for a text objective question.

Description of the Related Art

As computer technologies and education informatization are continuously advanced, computer and artificial intelligence technologies have been gradually applied in a variety of daily teaching activities, including those for actual scenarios such as teaching assistance and teaching evaluation. The main form currently used in China to evaluate situations of basic education and student studying is still various examinations or tests. In such a circumstance, teachers are under tremendous work pressure to check homework and score examination papers. In light of this, all kinds of automatic scoring systems have been gradually promoted and adopted in medium-, large-scale or important examinations or tests, and this type of system could reduce to a certain degree the examination paper scoring workload for teachers.

In existing automatic scoring systems, however, portions that are completely scored by a computer are mostly objective questions with a space to be filled (e.g. multiple choice questions), while for text objective questions like text completion questions, it is still necessary to gather a large number of teachers for scoring. For a large-scale examination, moreover, centralized training and testing need to be offered to the scoring teachers before scoring the examination papers. As a result, a conventional automatic scoring system still consumes significant human resources, and moreover, it is possible for unfair, unjust situations to occur in the scoring results due to subjective factors, such as style, moods, and mental status of different teachers, during the scoring process.

Summary of the Invention

Embodiments of the present invention provide an intelligent scoring method and system for a text objective question, so as to achieve automatic scoring of text objective questions, thereby reducing consumption of human resources and improving scoring efficiency and accuracy.

To this end, embodiments of the present invention provide the following technical solution:

Embodiments of the present invention provide an intelligent scoring method for a text objective question, comprising:

acquiring an answer image of a text objective question;

segmenting the answer image to obtain one or more segmentation results of an answer string to be identified;

determining whether any of the segmentation results has the same number of characters as that of the standard answer;

if not, determining that the answer is wrong;

otherwise, calculating identification confidence of the segmentation result having the same number of characters as that of the standard answer, and/or calculating the identification confidence of each character in the segmentation result having the same number of characters as that of the standard answer;

determining whether the answer is correct according to the calculated identification confidence.

Preferably, said acquiring an answer image of a text objective question comprises:

acquiring an image of an answer sheet;

according to the layout information of the answer sheet, segmenting and extracting a target answer region of the answer sheet image;

extracting an answer image of a text objective question from the target answer region.

Preferably, said acquiring an image of an answer sheet comprises:

using an optical mark reader, a high-speed portable scanner, or a mobile terminal device to acquire an image of an answer sheet.

Preferably, said segmenting the answer image to obtain one or more segmentation results of an answer string to be identified comprises:

performing fine segmentation on the answer image to obtain a plurality of fine segmentation sub-blocks;

combining the fine segmentation sub-blocks and calculating combination confidence;

determining combination results according to the confidence, and obtaining one or more segmentation results of an answer string to be identified.

Preferably, said calculating combination confidence comprises:

extracting a character feature of the character obtained from the combination;

using a rule statistical model obtained from pre-training and the character feature to calculate confidence of said combination.

Preferably, said calculating identification confidence of the segmentation result having the same number of characters as that of the standard answer comprises:

aligning the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

on the basis of an acoustical model of a complete character set and a general language model, performing handwriting decoding and identification on the segmentation result having the same number of characters as that of the standard answer, to obtain a likelihood score of each identification result;

selecting a likelihood score of a path with a decoding path consistent with the standard answer in an identification result;

calculating a posteriori score of said path, and using the posteriori score as the identification confidence of the segmentation result having the same number of characters as that of the standard answer;

correspondingly, said determining whether the answer is correct according to the calculated identification confidence comprises:

if there is any segmentation result having the same number of characters as that of the standard answer having an identification confidence greater than a first confidence threshold, determining that the answer is correct; otherwise, determining that the answer is wrong.

Preferably, said calculating identification confidence of each character in the segmentation result having the same number of characters as that of the standard answer comprises:

aligning the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

on the basis of an acoustical model of a complete character set, calculating a likelihood score of the identification result of each character in the segmentation result having the same number of characters as that of the standard answer;

selecting a likelihood score of the identification result of the character that is consistent with the standard answer in the identification results;

calculating a posteriori score of the selected identification result, and using the posteriori score as the identification confidence of the character;

correspondingly, said determining whether the answer is correct according to the calculated identification confidence comprises:

if the identification confidence is greater than a second confidence threshold for all characters in any segmentation result having the same number of characters as that of the standard answer, determining that the answer is correct; otherwise, determining that the answer is wrong.

Preferably, said calculating identification confidence of each character in the segmentation result having the same number of characters as that of the standard answer comprises:

aligning the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

on the basis of an acoustical model of a complete character set and a general language model, performing handwriting decoding and identification on the segmentation result having the same number of characters as that of the standard answer, to obtain a likelihood score of each identification result;

calculating a posteriori probability of each identification result, and, according to the posteriori probability of each identification result and for each character in the segmentation result, accumulating the posteriori probability that the identification result of said character in each identification result is consistent with the standard answer, and using the posteriori score as the confidence of the character;

correspondingly, said determining whether the answer is correct according to the calculated identification confidence comprises:

if the identification confidence is greater than a third confidence threshold for all characters in any segmentation result having the same number of characters as that of the standard answer, determining that the answer is correct; otherwise, determining that the answer is wrong.

Embodiments of the present invention further provide an intelligent scoring system for a text objective question, comprising: an image acquisition module, a segmentation module, a first determination module, a calculation module, a second determination module, and an output module, wherein:

said image acquisition module is configured to acquire an answer image of a text objective question;

said segmentation module is configured to segment the answer image to obtain one or more segmentation results of an answer string to be identified;

said first determination acquisition module is configured to determine whether any of the segmentation results obtained by said segmentation module has the same number of characters as that of the standard answer, and when the determination result is that there is no segmentation result having the same number of characters as that of the standard answer, trigger said output

module to output a prompt message that the answer is wrong; otherwise, trigger said calculation module to calculate identification confidence;

said calculation module comprises a first calculation module and/or a second calculation module; said first calculation module is configured to calculate identification confidence of the segmentation result having the same number of characters as that of the standard answer, and said second calculation module is configured to calculate the identification confidence of each character in the segmentation result having the same number of characters as that of the standard answer;

said second determination module is configured to determine whether the answer is correct according to the identification confidence calculated by said calculation module, and when it is determined that the answer is correct, trigger said output module to output a prompt message that the answer is correct; when it is determined that the answer is wrong, trigger said output module to output a prompt message that the answer is wrong.

Preferably, said image acquisition module comprises:

an image acquisition unit configured to acquire an image of an answer sheet;

an answer region extraction unit configured to, according to the layout information of the answer sheet, segment and extract a target answer region of the answer sheet image;

an answer content extraction unit configured to extract an answer image of a text objective question from the target answer region.

Preferably, said image acquisition unit is specifically an optical mark reader, a high-speed portable scanner, or a mobile terminal device.

Preferably, said segmentation module comprises:

a segmentation unit configured to perform fine segmentation on the answer image to obtain a plurality of fine segmentation sub-blocks;

a confidence calculation unit configured to combine the fine segmentation sub-blocks and calculate combination confidence;

a combination result determination unit configured to determine combination results according to the confidence, and obtain one or more segmentation results of an answer string to be identified.

Preferably, said confidence calculation unit comprises:

a combination subunit configured to combine the fine segmentation sub-blocks;

an extraction subunit configured to extract a character feature of the character obtained from the combination;

a calculation subunit configured to use a rule statistical model obtained from pre-training and the character feature to calculate confidence of said combination.

Preferably, said first calculation module comprises:

an alignment unit configured to align the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

a first identification unit configured to, on the basis of an acoustical model of a complete character set and a general language model, perform handwriting decoding and identification on the segmentation result having the same number of characters as that of the standard answer, to obtain a likelihood score of each identification result;

a first selection unit configured to select a likelihood score of a path with a decoding path consistent with the standard answer in an identification result;

a first calculation unit configured to calculate a posteriori score of said path, and use the posteriori score as the identification confidence of the segmentation result;

said second determination module is specifically configured to, if there is any segmentation result having the same number of characters as that of the standard answer having an identification confidence greater than a first confidence threshold, determine that the answer is correct; otherwise, determine that the answer is wrong.

Preferably, said second calculation module comprises:

an alignment unit configured to align the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

a second identification unit configured to, on the basis of an acoustical model of a complete character set, calculate a likelihood score of the identification result of each character in the segmentation result having the same number of characters as that of the standard answer;

a second selection unit configured to select a likelihood score of the identification result of the character that is consistent with the standard answer in the identification results;

a second calculation unit configured to calculate a posteriori score of the selected identification result, and use the posteriori score as the identification confidence of the character;

said second determination module is specifically configured to, if the identification confidence is greater than a second confidence threshold for all characters in any segmentation result having the same number of characters as that of the standard answer, determine that the answer is correct; otherwise, determine that the answer is wrong.

Preferably, said second calculation module comprises:

the alignment unit configured to align the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

the first identification unit configured to, on the basis of an acoustical model of a complete character set and a general language model, perform handwriting decoding and identification on the segmentation result having the same number of characters as that of the standard answer, to obtain a likelihood score of each identification result;

a third calculation unit configured to calculate a posteriori probability of each identification result, and, according to the posteriori probability of each identification result and for each character in the segmentation result having the same number of characters as that of the standard answer, accumulate the posteriori probability that the identification result of said character in each identification result is consistent with the standard answer, and use the posteriori score as the confidence of the character;

said second determination module is specifically configured to, if the identification confidence is greater than a third confidence threshold for all characters in any segmentation result having the same number of characters as that of the standard answer, determine that the answer is correct; otherwise, determine that the answer is wrong.

The intelligent scoring method and system for a text objective question provided in the embodiments of the present invention perform identification of handwritten character strings for a text objective question with a known standard answer by using the priori information of the answer, thereby achieving automatic scoring of the text objective question, and solving the problem that a conventional automatic scoring system is unable to use computers for fully automatic scoring of text objective questions, while manual scoring causes significant consumption of human resources, high working pressure on teachers and inaccurate scoring results due to subjective factors of teachers.

Brief Description of the Drawings

To more clearly describe technical solutions of the embodiments of the present application or the prior art, the accompanying drawings to be used in the embodiments will be introduced briefly below. Apparently, the accompanying drawings in the description below are only some embodiments recorded in the present invention, and to a person skilled in the art, other drawings may be derived on the basis of these accompanying drawings.

Fig. 1 is a flow chart of an intelligent scoring method for a text objective question in an embodiment of the present invention;

Fig. 2 is an example of segmenting an answer image in an embodiment of the present invention;

Fig. 3 is a flow chart of segmenting an answer image in an embodiment of the present invention;

Fig. 4 is a flow chart of calculating identification confidence in an embodiment of the present invention;

Fig. 5 is another flow chart of calculating identification confidence in an embodiment of the present invention;

Fig. 6 is another flow chart of calculating identification confidence in an embodiment of the present invention;

Fig. 7 is a schematic diagram of the structure of an intelligent scoring system for a text objective question in an embodiment of the present invention;

Fig. 8 is a structural block diagram of a first calculation module in an embodiment of the present invention;

Fig. 9 is a structural block diagram of a second calculation module in an embodiment of the present invention;

Fig. 10 is another structural block diagram of the second calculation module in an embodiment of the present invention.

Detailed Description of the Invention

To make a person skilled in the art better understand solutions in the embodiments of the present invention, the embodiments of the present invention will be further described in detail below with reference to the accompanying drawings and implementation modes.

The intelligent scoring method and system for a text objective question according to the embodiments of the present invention perform identification of handwritten character strings for an examination paper with text questions having standard answers, for example an examination paper with text completion questions, by using the priori information of the standard answers, thereby achieving automatic scoring of the text objective questions.

Fig. 1 is a flow chart of an intelligent scoring method for a text objective question in an embodiment of the present invention, which comprises the following steps:

Step 101, acquire an answer image of a text objective question.

Said answer image of a text objective question is an image of an answer character string, and in the embodiments of the present invention, said answer character string may be a Chinese character string, an English character string, etc.

The specific process to acquire an answer image is as follows:

(1) Acquire an image of an answer sheet.

To acquire an image of an answer sheet, an optical mark reader may be used for scanning, or a device, such as a high-speed portable scanner or a mobile terminal, may be used to take photos for acquisition thereof.

(2) According to the layout information of the answer sheet, segment and extract a target answer region of the answer sheet image.

In a practical application, prior to segmenting and extracting a target answer region, the answer sheet image may be pre-processed to extract an accurate target answer region. Said pre-processing may comprise performing operations, such as positioning, calibration, noise reduction, contrast enhancement, and graying, on the answer sheet image, and the specific processing method is the same as the pre-processing method for answer sheet images in an existing automatic scoring system, which will not be repeated herein.

The layout information of the answer sheet is known priori information, and if it is necessary to position the answer sheet image, positioning information of the answer sheet image may be further acquired, and according to the information and through edge detection, the target answer region can be accurately segmented and extracted.

(3) Extract an answer image of a text objective question from the target answer region.

When the target answer region is obtained, according to the layout information of the answer sheet and through edge detection, an answer image can be obtained, and the answer image is an image of the answer character string.

Step 102, segment the answer image to obtain one or more segmentation results of an answer string to be identified.

The specific segmenting process will be described in detail later.

In addition, it should be noted that, in a practical application, prior to segmenting the answer image, the answer image may be pre-processed to obtain more accurate segmentation results. Said pre-processing may comprise: performing binarization on the answer image, correcting inclined handwriting, thinning handwriting, etc.

Step 103, determine whether any of the segmentation results has the same number of characters as that of the standard answer. If yes, go to Step 104; otherwise, go to Step 106.

Since there will be a number of different combination results, the plurality of segmentation results obtained in Step 102 will have different numbers of characters, while the segmentation result having the same number of characters as that of the standard answer is the answer that is most likely correct. Since the solution of the present invention is for text objective questions having standard answers, it can be determined that an answer is wrong if its number of characters is different from that of the standard answer. If a segmentation result has the same number of characters as that of the standard answer, then it is necessary to further determine if said answer is correct.

Step 104, calculate identification confidence of the segmentation result having the same number of characters as that of the standard answer, and/or calculate the identification confidence of each character in the segmentation result having the same number of characters as that of the standard answer.

Step 105, determine whether the answer is correct according to the calculated identification confidence.

There may be a variety of ways to calculate identification confidence, and accordingly, corresponding determination can be made regarding whether the answer is correct according to identification confidence obtained through different ways of calculation, which will be specifically described in detail below.

Step 106, determine that the answer is wrong.

The intelligent scoring method for a text objective question provided in the embodiments of the present invention performs identification of handwritten character strings for a text objective question with a known standard answer by using the priori information of the answer, thereby achieving automatic scoring of the text objective question, and solving the problem that a conventional automatic scoring system is unable to use computers for fully automatic scoring of text objective questions, while manual scoring causes significant consumption of human resources, high working pressure on teachers and inaccurate scoring results due to subjective factors of teachers.

Fig. 3 is a flow chart of segmenting an answer image in an embodiment of the present invention, which comprises the following steps:

Step 301, perform fine segmentation on the answer image to obtain a plurality of fine segmentation sub-blocks.

For example, start 8-neighborhood black expansion from the black pixel at the most upper left corner of the answer image, such that the entire image is divided into several connected sub-regions formed by black pixels, an example of segmentation is shown in Fig. 2, and it can be seen that the original image of a character string is segmented into several segments after segmentation of connected regions is performed on the black handwriting part, all these segments are parts that form individual characters, which may be radicals or may be a single handwriting portion depending on the way of writing, and these segments can be combined to form different characters.

Step 302, combine the fine segmentation sub-blocks and calculate combination confidence.

For example, exhaustive combination may be performed on the fine segmentation sub-blocks, namely all fine segmentation sub-blocks that have the possibility of combination will be

combined one by one, for example, for 5 fine segmentation sub-blocks, there are several combinations as follows:

(1) Assume that there is one character, then combine the fine segmentation sub-blocks 1, 2, 3, 4, and 5;

(2) Assume that there are two characters, then combine the fine segmentation sub-blocks 1, 2, 3, and 4; combine the fine segmentation sub-blocks 1, 2, and 3, and combine the fine segmentation sub-blocks 4 and 5; combine the fine segmentation sub-blocks 1 and 2, and combine the fine segmentation sub-blocks 3, 4, and 5; combine the fine segmentation sub-blocks 2, 3, 4, and 5;

The same operation is performed in this way until it is assumed that there are five characters.

Said combination confidence represents the accuracy of characters obtained from combination, and specifically, features such as height, width, height/width ratio, inter-character distance, and intra-character distance of the characters after combination can be extracted, a likelihood score can be obtained according to a rule statistical model pre-trained by the system, and said score is used as the confidence of a current combination result.

Said rule statistical model is a statistical model trained according to the extracted features such as height, width, height/width ratio, inter-character distance, and intra-character distance of the characters after the training data are segmented, and said model may be GMM (Gaussian Mixture Model) or SVM (Support Vector Machine).

The calculation of combination confidence is to calculate a likelihood score calculated through the rule statistical model with the features extracted from the combination result, namely to combine the scores, and determine the combination confidence according to said score, or directly use said score as a corresponding combination confidence.

Step 303, determine combination results according to the confidence, and obtain one or more segmentation results of an answer string to be identified.

Specifically, if the confidence is greater than a set threshold, it is concluded that said combination is credible, otherwise it is concluded that said combination is not credible. Subsequently, one or more answer character strings to be identified are obtained according to the credible combination results.

It should be noted that, in a practical application, prior to combination or determining combination confidence, some determination rules may be further set according to experience or experiments, for example, the handwriting of one Chinese character does not have more than 3 fine segmentation sub-blocks, so as to further assist or guide the completion of determination whether segmentation results of a character string are correct, and improve the accuracy of determination.

In the embodiments of the present invention, it is necessary to calculate identification confidence of each segmentation result having the same number of characters as that of the standard answer, and/or calculate the identification confidence of each character in each segmentation result having the same number of characters as that of the standard answer, and determine whether the answer is correct according to the calculated identification confidence. In a practical application, there may be a variety of ways of calculation and determination, which will be described below, respectively.

Fig. 4 is a flow chart of calculating identification confidence in an embodiment of the present invention. In said embodiment, it is necessary to calculate identification likelihood score of each segmentation result, and then calculate identification confidence of said segmentation result according to said identification likelihood score.

The specific process of calculating identification confidence of each segmentation result having the same number of characters as that of the standard answer comprises the following steps:

Step 401, align a segmentation result with the text string of the standard answer.

In other words, align each segment in the segmentation result sequentially with each character in the text string of the standard answer one by one, and each segment in the segment sequence represents a character.

Step 402, on the basis of an acoustical model of a complete character set and a general language model, perform handwriting decoding and identification on the segmentation result to obtain a likelihood score of each identification result.

The language model may a N-Gram model with a specific calculation equation as follows:

$$p(X, W_k) = \prod_{i=1}^M p(x_i | w_{ki}) p(w_{ki} | h_1^{i-1}), k = 1, 2, \dots, K \quad (1)$$

Wherein, $p(X, W_k)$ represents a likelihood score of the k^{th} identification result of the entire sentence X of the segmentation result; M is the total number of segments in the segmentation result; K is the number of identification results of the entire sentence; $p(x_i | w_{ki})$ represents a likelihood score that the i^{th} segment x_i is identified as the i^{th} character w_{ki} in a path W_k ; $p(w_{ki} | h_1^{i-1})$ represents priori that the given 1 to $i-1$ identification results are identified as w_{ki} .

Step 403, select a likelihood score of a path with a decoding path consistent with the standard answer in an identification result.

Step 404, calculate a posteriori score of said path, and use the posteriori score as the identification confidence of the segmentation result.

Specifically, first select a likelihood score of a path with an identification decoding path consistent with the standard answer, then calculate identification confidence of the entire sentence of the segmentation result with the calculation equation as follows:

$$p(W_y | X) = \frac{\prod_{i=1}^M p(x_i | w_{yi}) p(w_{yi} | h_1^{i-1})}{\sum_{k=1}^K \prod_{i=1}^M p(x_i | w_{ki}) p(w_{ki} | h_1^{i-1})}, k = 1, 2, \dots, K \quad (2)$$

Wherein, W_y represents an identification decoding path consistent with the standard answer, $p(x_i | w_{yi})$ represents a likelihood score that the i^{th} segment x_i is identified as the i^{th} character w_{yi} in a path W_y consistent with the standard answer; $p(w_{yi} | h_1^{i-1})$ represents priori that the given 1 to $i-1$ identification results are identified as w_{yi} consistent with the standard answer; the value of K may be the number of all identification results. Furthermore, to reduce the amount of calculation, a relatively small value, e.g. 50, may be properly selected for K , and the selection of said value may be determined according to experience or experimental results.

Correspondingly, after identification confidence of each segmentation result is obtained using the above method, whether the answer is correct is determined as follows: if there is any segmentation result having an identification confidence greater than a first confidence threshold, it is determined that the answer is correct; otherwise, it is determined that the answer is wrong.

For example, the standard answer text is “Yellow River Enters Sea Flow,” with respect to the segmentation results of the string to be identified, an acoustical model and a language model are used to perform handwriting decoding and identification thereon, assume that 3 identification results are obtained, which are “Yellow River Enters Sea Flow,” “Yellow River Human Sea Flow,” and “Yellow River Enters Ocean Flow,” respectively, and the corresponding likelihood scores thereof are 90, 54, and 36, respectively, select the likelihood score 90 of the path “Yellow River Enters Sea Flow” that has an identification decoding path consistent with the standard answer in the identification results, and calculate the posteriori score of said path to be 0.5. When determining whether the answer is correct or wrong according to the identification confidence, it is to determine whether the posteriori score of the identification result, Yellow River Enters Sea Flow,” consistent with the standard answer is greater than a first confidence threshold.

Fig. 5 is a flow chart of calculating identification confidence in an embodiment of the present invention. In said embodiment, it is necessary to calculate identification confidence of each character in each segmentation result, respectively.

The specific process of calculating identification confidence of each character in each segmentation result having the same number of characters as that of the standard answer comprises the following steps:

Step 501, align a segmentation result with the text string of the standard answer.

In other words, align each segment (each segment represents a character) in the segmentation result sequentially with each character in the text string of the standard answer one by one. For example, the standard answer is “Shanghai,” then the first segment in the segmentation result is made to correspond to “Shang,” and the second segment in the segmentation result is made to correspond to “hai.”

Step 502, on the basis of an acoustical model of a complete character set, calculate a likelihood score $p(x_i | w_j)$ of the identification result of each character in the segmentation result.

Wherein, x_i represents the i^{th} ($i=1, 2, \dots, M$) segment, M is the total number of segments in the segmentation result; w_j represents that the i^{th} segment is identified as a W_j ($j=1, 2, \dots, N$) character after an acoustical model, and N is the number of identification results.

It should be noted that, to reduce the amount of calculation in actual calculation, the value of N may be properly reduced, e.g. set to 50.

Step 503, select a likelihood score of the identification result of the character that is consistent with the standard answer in the identification results.

Step 504, calculate a posteriori score of the selected identification result, and use the posteriori score as the identification confidence of the character.

Specifically, select a likelihood score of an identification result consistent with the standard answer in the identification results of the segments, then calculate posteriori probability of the selected identification result, which is used as the identification confidence of the segment (i.e. character), and its calculation equation is as follows:

$$p(w_{yi} | x_i) = \frac{p(x_i | w_{yi})}{\sum_{j=1}^N p(x_i | w_j)} \quad (3)$$

Wherein, $p(w_{yi} | x_i)$ represents a posteriori score that the i^{th} segment x_i is identified as the i^{th} character w_{yi} in a path W_y consistent with the standard answer.

Correspondingly, according to the identification confidence of each character in each segmentation result obtained above, whether the answer is correct is determined as follows:

if the identification confidence is greater than a second confidence threshold for all characters in any segmentation result, it is determined that the answer is correct; otherwise, it is determined that the answer is wrong.

Fig. 6 is a flow chart of calculating identification confidence in an embodiment of the present invention. In said embodiment, it is similarly necessary to calculate identification confidence of each character in each segmentation result, respectively, but the calculation method is different from the embodiment shown in Fig. 5, and specifically comprises the following steps:

Step 601, align a segmentation result with the text string of the standard answer.

Step 602, on the basis of an acoustical model of a complete character set and a general language model, perform handwriting decoding and identification on the segmentation result to obtain a likelihood score of each identification result.

See the above equation (1) for the specific calculation equation.

Step 603, calculate a posteriori probability of each identification result.

The specific calculation equation is as follows:

$$p(W_k | X) = \frac{\prod_{i=1}^M p(x_i | w_{ki}) p(w_{ki} | h_1^{i-1})}{\sum_{k=1}^K \prod_{i=1}^M p(x_i | w_{ki}) p(w_{ki} | h_1^{i-1})} \quad (4)$$

Wherein, $p(W_k | X)$ represents posteriori probability of the k^{th} identification result, and other parameters have the same meanings as those of the corresponding parameters above.

Step 604, according to the posteriori probability of each identification result and for each character in the segmentation result, accumulate the posteriori probability that the identification result of said character in each identification result is consistent with the standard answer, and use the posteriori score as the confidence of the character.

The specific calculation equation is as follows:

$$p(w_{yi} | X) = \sum_{\substack{w_{ji}=w_{yi}, k=1 \\ j=1,2,\dots,N}}^K p(W_k | X), \quad j=1,2,\dots,N \quad (5)$$

Wherein, $p(w_{yi} | X)$ represents posteriori probability that the identification result of the character i in each identification result is consistent with the standard answer; other parameters have the same meanings as those of the corresponding parameters above. The value of K may be the total number of all identification results. Furthermore, to reduce the amount of calculation, a relatively small value, e.g. 50, may be properly selected for K , and the selection of said value may be determined according to experience or experimental results.

For example, the standard answer text is “Yellow River Enters Sea Flow,” for easy description, assume that 3 identification results are obtained through handwriting identification (i.e. $K=3$), and these 3 identification results are: the first identification result “Yellow River Enters Sea Flow” with a likelihood score of 0.5, the second identification result “Yellow River Human Sea Flow” with a likelihood score of 0.3, and the third identification result “Yellow River Enters Ocean Flow” with a likelihood score of 0.2, respectively. In such a circumstance, the posteriori probability score is $0.5+0.3+0.2=1.0$ for the three characters, “Yellow,” “River,” and “Flow,” the posteriori probability score is $0.5+0.2=0.7$ for “Enters,” and the posteriori probability score is $0.5+0.3=0.8$ for “Sea.”

Correspondingly, according to the identification confidence of each character in each segmentation result obtained using the above method, whether the answer is correct is determined as follows:

if the identification confidence is greater than a third confidence threshold for all characters in any segmentation result, it is determined that the answer is correct; otherwise, it is determined that the answer is wrong.

It should be noted that the first confidence threshold, the second confidence threshold, and the third confidence threshold mentioned above may be identical, or may be different, which is not defined by the embodiments of the present invention. In a practical application, moreover, the above three solutions may be combined arbitrarily. If two of the solutions are adopted, then whether the answer is correct may be determined depending on whether all determination conditions in these two solutions are satisfied, if they are all satisfied, then it is determined that the answer is correct; otherwise, it is determined that the answer is wrong. If three of the solutions are adopted, then it is determined that the answer is correct if all determination conditions in these three solutions are satisfied, or if the determination conditions in any two of the solutions are satisfied; otherwise, it is determined that the answer is wrong.

Correspondingly, embodiments of the present invention further provide an intelligent scoring system for a text objective question, as shown in Fig. 7, which is a schematic diagram of the structure of an intelligent scoring system for a text objective question in an embodiment of the present invention.

In said embodiment, said system comprises: an image acquisition module 701, a segmentation module 702, a first determination module 703, a calculation module 704, a second determination module 705, and an output module 706. Wherein, the calculation module 704 comprises a first calculation module 741 and a second calculation module 742.

The above image acquisition module 701 is configured to acquire an answer image of a text objective question;

The above segmentation module 702 is configured to segment the answer image that is acquired by the image acquisition module 701 to obtain one or more segmentation results of an answer string to be identified;

The above first determination acquisition module 703 is configured to determine whether any of the segmentation results obtained by said segmentation module 702 has the same number of characters as that of the standard answer, and when the determination result is that there is no segmentation result having the same number of characters as that of the standard answer, trigger said output module 706 to output a prompt message that the answer is wrong; otherwise, trigger said calculation module 704 to calculate identification confidence;

The above first calculation module 741 is configured to calculate identification confidence of the segmentation result having the same number of characters as that of the standard answer, and said second calculation module 742 is configured to calculate the identification confidence of each character in the segmentation result having the same number of characters as that of the standard answer;

The above second determination module 705 is configured to determine whether the answer is correct according to the identification confidence calculated by said calculation module 704, and when it is determined that the answer is correct, trigger said output module 706 to output a prompt message that the answer is correct; when it is determined that the answer is wrong, trigger said output module 706 to output a prompt message that the answer is wrong.

Said answer image of a text objective question is an image of an answer character string, and in the embodiments of the present invention, said answer character string may be a Chinese character string, an English character string, etc.

One embodiment of the above image acquisition module 701 may comprise the following units:

- an image acquisition unit configured to acquire an image of an answer sheet;

- an answer region extraction unit configured to, according to the layout information of the answer sheet, segment and extract a target answer region of the answer sheet image;

- an answer content extraction unit configured to extract an answer image of a text objective question from the target answer region. Specifically, when the answer region extraction unit obtains the target answer region, according to the layout information of the answer sheet and through edge point detection, an answer image can be obtained, and the answer image is an image of the answer character string.

The above image acquisition unit is specifically an optical mark reader, a high-speed portable scanner, or a mobile terminal device. In other words, an optical mark reader may be used for scanning, or a device, such as a high-speed portable scanner or a mobile terminal, may be used to take photos to acquire an answer sheet image.

One embodiment of the above segmentation module 702 may comprise the following units:

- a segmentation unit configured to perform fine segmentation on the answer image to obtain a plurality of fine segmentation sub-blocks;

- a confidence calculation unit configured to combine the fine segmentation sub-blocks and calculate combination confidence;

- a combination result determination unit configured to determine combination results according to the confidence, and obtain one or more segmentation results of an answer string to be identified. Specifically, if the confidence is greater than a set threshold, it is concluded that said combination is credible, otherwise it is concluded that said combination is not credible. Subsequently, one or more answer character strings to be identified are obtained according to the credible combination results.

It should be noted that one embodiment of the above confidence calculation unit may comprise: a combination subunit, an extraction subunit, and a calculation subunit. Wherein, the combination subunit is configured to combine the fine segmentation sub-blocks, there may be a variety of ways to combine fine segmentation sub-blocks, for example, exhaustive combination, as long as no potential combination result is missed. The extraction subunit is configured to extract a character feature of the character obtained from the combination. The calculation subunit is configured to use a rule statistical model obtained from pre-training and the character feature to calculate confidence of said combination.

Said combination confidence represents the accuracy of characters obtained from combination, and specifically, features such as height, width, height/width ratio, inter-character distance, and intra-character distance of the characters after combination can be extracted, a likelihood score can be obtained according to a rule statistical model pre-trained by the system, and said score is used as the confidence of a current combination result.

Said rule statistical model is a statistical model trained according to the extracted features such as height, width, height/width ratio, inter-character distance, and intra-character distance of the characters after the training data are segmented, and said model may be GMM or SVM.

The calculation of combination confidence is to calculate a likelihood score calculated through the rule statistical model with the features extracted from the combination result, namely to combine the scores, and determine the combination confidence according to said score; naturally, said score may be directly used as a corresponding combination confidence.

In addition, it should be noted that, in a practical application, the system may further comprise a pre-processing module (not shown) disposed between the image acquisition module 701 and the segmentation module 702, and configured to, before the segmentation module 702 segments the answer image, pre-process the answer image to obtain more accurate segmentation results. Said pre-processing may comprise: performing binarization on the answer image, correcting inclined handwriting, thinning handwriting, etc.

The intelligent scoring system for a text objective question provided in the embodiments of the present invention performs identification of handwritten character strings for a text objective question with a known standard answer by using the priori information of the answer, thereby achieving automatic scoring of the text objective question, and solving the problem that a conventional automatic scoring system is unable to use computers for fully automatic scoring of text objective questions, while manual scoring causes significant consumption of human resources, high working pressure on teachers and inaccurate scoring results due to subjective factors of teachers.

In Fig. 7, the first calculation module 741 is configured to calculate identification confidence of each segmentation result having the same number of characters as that of the standard answer, and the second calculation module 742 is configured to calculate the identification confidence of each character in each segmentation result having the same number of characters as that of the standard answer. In a practical application, the system may choose either the first calculation module 741 or the second calculation module 742, or may

simultaneously comprise both the first calculation module 741 and the second calculation module 742, which is not defined by the embodiments of the present invention. Correspondingly, when the second determination module 705 determines whether the answer is correct, it may determine according to the calculation result from one of the two, or may make a comprehensive determination according to the calculation results from both of the two.

The specific structures of the first calculation module 741 and the second calculation module 742 will be described in detail below through examples.

Fig. 8 is a structural block diagram of a first calculation module in an embodiment of the present invention.

In said embodiment, said first calculation module 741 comprises:

an alignment unit 801 configured to align the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

a first identification unit 802 configured to, on the basis of an acoustical model of a complete character set and a general language model, perform handwriting decoding and identification on the segmentation result having the same number of characters as that of the standard answer, to obtain a likelihood score of each identification result;

a first selection unit 803 configured to select a likelihood score of a path with a decoding path consistent with the standard answer in an identification result;

a first calculation unit 804 configured to calculate a posteriori score of said path, and use the posteriori score as the identification confidence of the segmentation result having the same number of characters as that of the standard answer.

Correspondingly, according to the calculation result from the above first calculation module 741, the second determination module 704 in Fig. 7 determines that the answer is correct if there is any segmentation result having the same number of characters as that of the standard answer having an identification confidence greater than a first confidence threshold; otherwise, determines that the answer is wrong.

Fig. 9 is a structural block diagram of a second calculation module in an embodiment of the present invention.

In said embodiment, said second calculation module 910 comprises:

an alignment unit 801 configured to align the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

a second identification unit 912 configured to, on the basis of an acoustical model of a complete character set, calculate a likelihood score of the identification result of each character in the segmentation result having the same number of characters as that of the standard answer;

a second selection unit 913 configured to select a likelihood score of the identification result of the character that is consistent with the standard answer in the identification results;

a second calculation unit 914 configured to calculate a posteriori score of the selected identification result, and use the posteriori score as the identification confidence of the character.

Correspondingly, according to the calculation result from the above second calculation module 910, the second determination module 704 in Fig. 7 determines that the answer is correct if the identification confidence is greater than a second confidence threshold for all characters in any segmentation result having the same number of characters as that of the standard answer; otherwise, determines that the answer is wrong.

Fig. 10 is another structural block diagram of the second calculation module in an embodiment of the present invention.

In said embodiment, said second calculation module 920 comprises:

the alignment unit 801 configured to align the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

the first identification unit 802 configured to, on the basis of an acoustical model of a complete character set and a general language model, perform handwriting decoding and identification on the segmentation result having the same number of characters as that of the standard answer, to obtain a likelihood score of each identification result;

a third calculation unit 923 configured to calculate a posteriori probability of each identification result, and, according to the posteriori probability of each identification result and for each character in the segmentation result having the same number of characters as that of the standard answer, accumulate the posteriori probability that the identification result of said character in each identification result is consistent with the standard answer, and use the posteriori score as the confidence of the character.

Correspondingly, according to the calculation result from the above second calculation module 920, the second determination module 704 in Fig. 7 determines that the answer is correct if the identification confidence is greater than a third confidence threshold for all characters in any segmentation result having the same number of characters as that of the standard answer; otherwise, determines that the answer is wrong.

It should be noted that the first confidence threshold, the second confidence threshold, and the third confidence threshold mentioned above may be identical, or may be different, which is not defined by the embodiments of the present invention. In a practical application, moreover, if the first calculation module and the second calculation module are adopted simultaneously, then whether the answer is correct may be determined by the second determination module 704 depending on whether all determination conditions in these two solutions are satisfied, if they are

all satisfied, then it is determined that the answer is correct; otherwise, it is determined that the answer is wrong.

The embodiments of the present invention are described in a progressive manner, the identical or similar parts among the embodiments may be referred to by each other, and each embodiment focuses on the description of different parts from other embodiments. The system embodiments described above are only illustrative, wherein the modules described as separate parts may or may not be physically separate, and the parts shown as units may or may not be physical units, namely they may be located at one place, or may be distributed on a plurality of network units. Some or all of the modules may be selected according to actual need to achieve the objectives of the solutions of the embodiments. Moreover, the functions provided by some of the modules may also be implemented by software, and some modules may be shared with the modules with the same functions in existing devices (e.g. personal computer, tablet computer, and cell phone). A person skilled in the art may understand and implement the above without innovative effort.

The embodiments of the present invention are described in detail above, specific implementation modes are used herein to describe the present invention, and the description of the above embodiments is just used to help understand the method and the device of the present invention; meanwhile, to a person skilled in the art, modifications may be made to the specific implementation modes and application range on the basis of the concept of the present invention. In summary, the content of the description shall not be construed as limitations to the present invention.

Claims

1. An intelligent scoring method for a text objective question, characterized in that it comprises:

- acquiring an answer image of a text objective question;
- segmenting the answer image to obtain one or more segmentation results of an answer string to be identified;
- determining whether any of the segmentation results has the same number of characters as that of the standard answer;
- if not, determining that the answer is wrong;
- otherwise, calculating identification confidence of the segmentation result having the same number of characters as that of the standard answer, and/or calculating the identification confidence of each character in the segmentation result having the same number of characters as that of the standard answer;
- determining whether the answer is correct according to the calculated identification confidence.

2. The method according to Claim 1, characterized in that said acquiring an answer image of a text objective question comprises:

- acquiring an image of an answer sheet;
- according to the layout information of the answer sheet, segmenting and extracting a target answer region of the answer sheet image;
- extracting an answer image of a text objective question from the target answer region.

3. The method according to Claim 2, characterized in that said acquiring an image of an answer sheet comprises:

- using an optical mark reader, a high-speed portable scanner, or a mobile terminal device to acquire an image of an answer sheet.

4. The method according to Claim 1, characterized in that said segmenting the answer image to obtain one or more segmentation results of an answer string to be identified comprises:

- performing fine segmentation on the answer image to obtain a plurality of fine segmentation sub-blocks;
- combining the fine segmentation sub-blocks and calculating combination confidence;
- determining combination results according to the confidence, and obtaining one or more segmentation results of an answer string to be identified.

5. The method according to Claim 4, characterized in that said calculating combination confidence comprises:

- extracting a character feature of the character obtained from the combination;
- using a rule statistical model obtained from pre-training and the character feature to calculate confidence of said combination.

6. The method according to any one of Claims 1 to 5, characterized in that, said calculating identification confidence of the segmentation result having the same number of characters as that of the standard answer comprises:

aligning the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

on the basis of an acoustical model of a complete character set and a general language model, performing handwriting decoding and identification on the segmentation result having the same number of characters as that of the standard answer, to obtain a likelihood score of each identification result;

selecting a likelihood score of a path with a decoding path consistent with the standard answer in an identification result;

calculating a posteriori score of said path, and using the posteriori score as the identification confidence of the segmentation result having the same number of characters as that of the standard answer;

said determining whether the answer is correct according to the calculated identification confidence comprises:

if there is any segmentation result having the same number of characters as that of the standard answer having an identification confidence greater than a first confidence threshold, determining that the answer is correct; otherwise, determining that the answer is wrong.

7. The method according to any one of Claims 1 to 5, characterized in that, said calculating identification confidence of each character in the segmentation result having the same number of characters as that of the standard answer comprises:

aligning the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

on the basis of an acoustical model of a complete character set, calculating a likelihood score of the identification result of each character in the segmentation result having the same number of characters as that of the standard answer;

selecting a likelihood score of the identification result of the character that is consistent with the standard answer in the identification results;

calculating a posteriori score of the selected identification result, and using the posteriori score as the identification confidence of the character;

said determining whether the answer is correct according to the calculated identification confidence comprises:

if the identification confidence is greater than a second confidence threshold for all characters in any segmentation result having the same number of characters as that of the standard answer, determining that the answer is correct; otherwise, determining that the answer is wrong.

8. The method according to any one of Claims 1 to 5, characterized in that, said calculating identification confidence of each character in the segmentation result having the same number of characters as that of the standard answer comprises:

aligning the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

on the basis of an acoustical model of a complete character set and a general language model, performing handwriting decoding and identification on the segmentation result having the same number of characters as that of the standard answer, to obtain a likelihood score of each identification result;

calculating a posteriori probability of each identification result, and, according to the posteriori probability of each identification result and for each character in the segmentation result, accumulating the posteriori probability that the identification result of said character in each identification result is consistent with the standard answer, and using the posteriori score as the confidence of the character;

said determining whether the answer is correct according to the calculated identification confidence comprises:

if the identification confidence is greater than a third confidence threshold for all characters in any segmentation result having the same number of characters as that of the standard answer, determining that the answer is correct; otherwise, determining that the answer is wrong.

9. An intelligent scoring system for a text objective question, characterized in that it comprises: an image acquisition module, a segmentation module, a first determination module, a calculation module, a second determination module, and an output module, wherein:

said image acquisition module is configured to acquire an answer image of a text objective question;

said segmentation module is configured to segment the answer image acquired by said image acquisition module to obtain one or more segmentation results of an answer string to be identified;

said first determination acquisition module is configured to determine whether any of the segmentation results obtained by said segmentation module has the same number of characters as that of the standard answer, and when the determination result is that there is no segmentation result having the same number of characters as that of the standard answer, trigger said output module to output a prompt message that the answer is wrong; otherwise, trigger said calculation module to calculate identification confidence;

said calculation module comprises a first calculation module and/or a second calculation module; said first calculation module is configured to calculate identification confidence of the segmentation result having the same number of characters as that of the standard answer, and said second calculation module is configured to calculate the identification confidence of each character in the segmentation result having the same number of characters as that of the standard answer;

said second determination module is configured to determine whether the answer is correct according to the identification confidence calculated by said calculation module, and when it is determined that the answer is correct, trigger said output module to output a prompt message that the answer is correct; when it is determined that the answer is wrong, trigger said output module to output a prompt message that the answer is wrong.

10. The system according to Claim 9, characterized in that said image acquisition module comprises:

an image acquisition unit configured to acquire an image of an answer sheet;

an answer region extraction unit configured to, according to the layout information of the answer sheet, segment and extract a target answer region of the answer sheet image;

an answer content extraction unit configured to extract an answer image of a text objective question from the target answer region.

11. The system according to Claim 10, characterized in that said image acquisition unit is specifically an optical mark reader, a high-speed portable scanner, or a mobile terminal device.

12. The system according to Claim 9, characterized in that said segmentation module comprises:

- a segmentation unit configured to perform fine segmentation on the answer image to obtain a plurality of fine segmentation sub-blocks;

- a confidence calculation unit configured to combine the fine segmentation sub-blocks and calculate combination confidence;

- a combination result determination unit configured to determine combination results according to the confidence, and obtain one or more segmentation results of an answer string to be identified.

13. The system according to Claim 12, characterized in that said confidence calculation unit comprises:

- a combination subunit configured to combine the fine segmentation sub-blocks;

- an extraction subunit configured to extract a character feature of the character obtained from the combination;

- a calculation subunit configured to use a rule statistical model obtained from pre-training and the character feature to calculate confidence of said combination.

14. The system according to any one of Claims 9 to 13, characterized in that said first calculation module comprises:

- an alignment unit configured to align the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

- a first identification unit configured to, on the basis of an acoustical model of a complete character set and a general language model, perform handwriting decoding and identification on the segmentation result having the same number of characters as that of the standard answer, to obtain a likelihood score of each identification result;

- a first selection unit configured to select a likelihood score of a path with a decoding path consistent with the standard answer in an identification result;

- a first calculation unit configured to calculate a posteriori score of said path, and use the posteriori score as the identification confidence of the segmentation result;

said second determination module is specifically configured to, if there is any segmentation result having the same number of characters as that of the standard answer having an identification confidence greater than a first confidence threshold, determine that the answer is correct; otherwise, determine that the answer is wrong.

15. The system according to any one of Claims 9 to 13, characterized in that said second calculation module comprises:

- an alignment unit configured to align the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

- a second identification unit configured to, on the basis of an acoustical model of a complete character set, calculate a likelihood score of the identification result of each character in the segmentation result having the same number of characters as that of the standard answer;

a second selection unit configured to select a likelihood score of the identification result of the character that is consistent with the standard answer in the identification results;

a second calculation unit configured to calculate a posteriori score of the selected identification result, and use the posteriori score as the identification confidence of the character;

said second determination module is specifically configured to, if the identification confidence is greater than a second confidence threshold for all characters in any segmentation result having the same number of characters as that of the standard answer, determine that the answer is correct; otherwise, determine that the answer is wrong.

16. The system according to any one of Claims 9 to 13, characterized in that said second calculation module comprises:

the alignment unit configured to align the segmentation result having the same number of characters as that of the standard answer with the text string of the standard answer;

the first identification unit configured to, on the basis of an acoustical model of a complete character set and a general language model, perform handwriting decoding and identification on the segmentation result having the same number of characters as that of the standard answer, to obtain a likelihood score of each identification result;

a third calculation unit configured to calculate a posteriori probability of each identification result, and, according to the posteriori probability of each identification result and for each character in the segmentation result having the same number of characters as that of the standard answer, accumulate the posteriori probability that the identification result of said character in each identification result is consistent with the standard answer, and use the posteriori score as the confidence of the character;

said second determination module is specifically configured to, if the identification confidence is greater than a third confidence threshold for all characters in any segmentation result having the same number of characters as that of the standard answer, determine that the answer is correct; otherwise, determine that the answer is wrong.