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(54) **METHOD OF ANALYSING STROKE IMAGES**

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(57) **ABSTRACT**

A plurality of brain atlases **1**, **2**, **3** are co-registered **4**, and mapped **8** to a scan of a brain. The mapping is then tested **9** to determine the presence of a stroke, and whether it is ischemic or hemorrhagic. This provides an accurate way of identifying strokes using patient data which is particularly suitable for use in an emergency situation such as the emergency department of a hospital.

1

Atlas of brain anatomy

2

Atlas of blood supply territories

3

Atlas of cerebral vasculature

5

Read scan

Co-register atlases

4

6

Extract brain

7

Calculate MSP

8

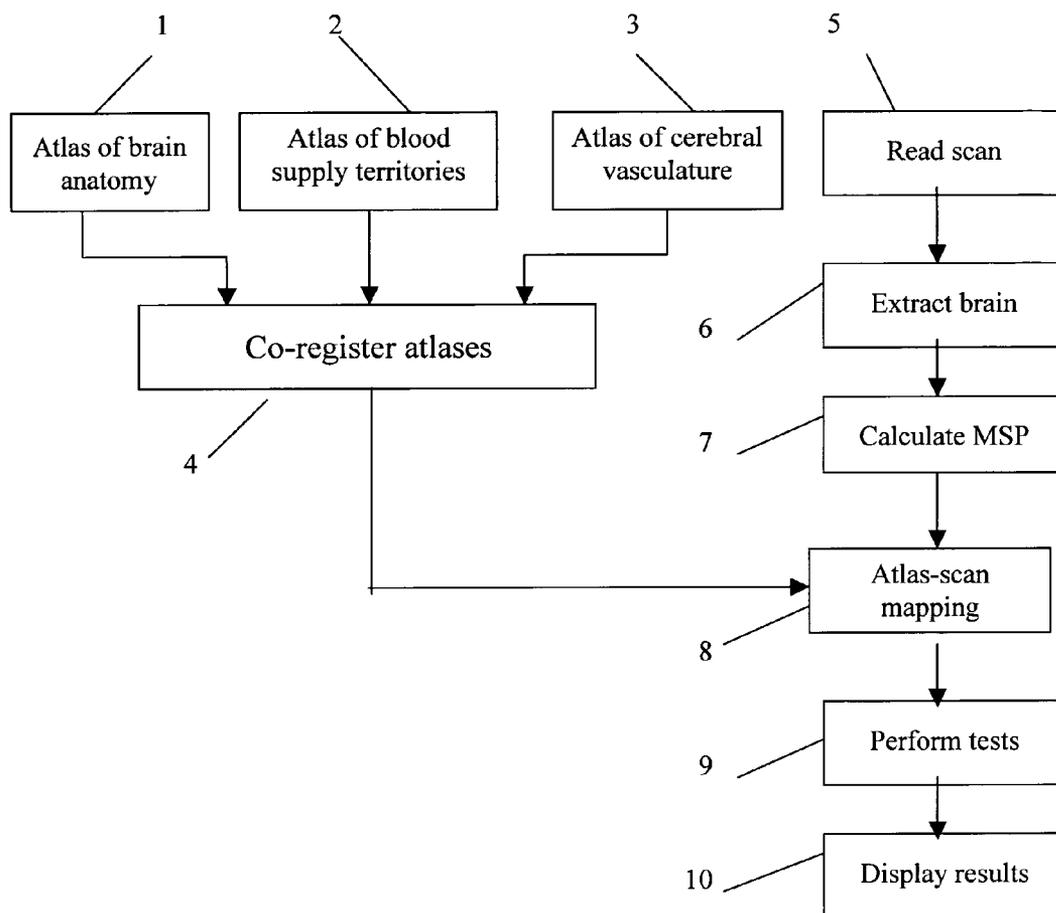Atlas-scan mapping
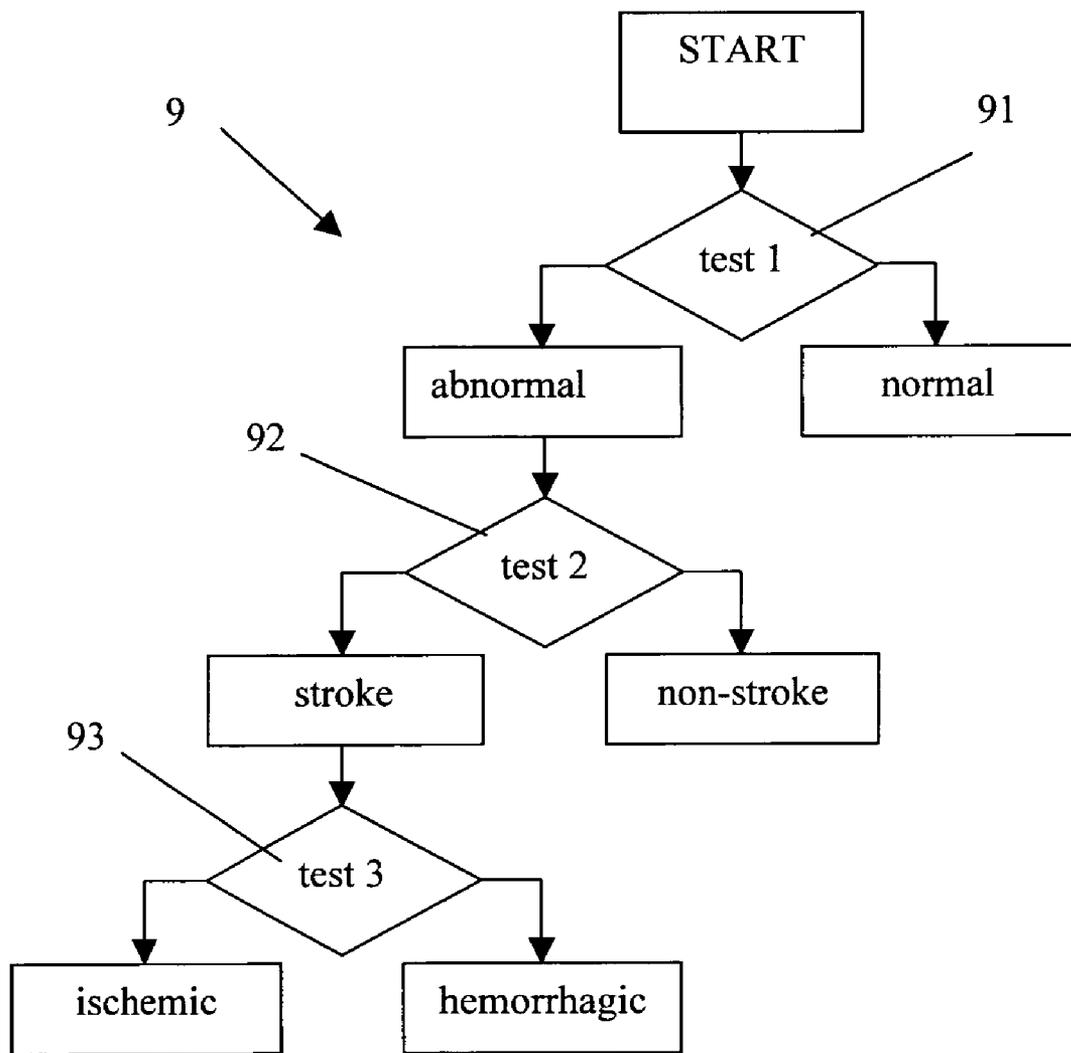
9

Perform tests

10

Display results
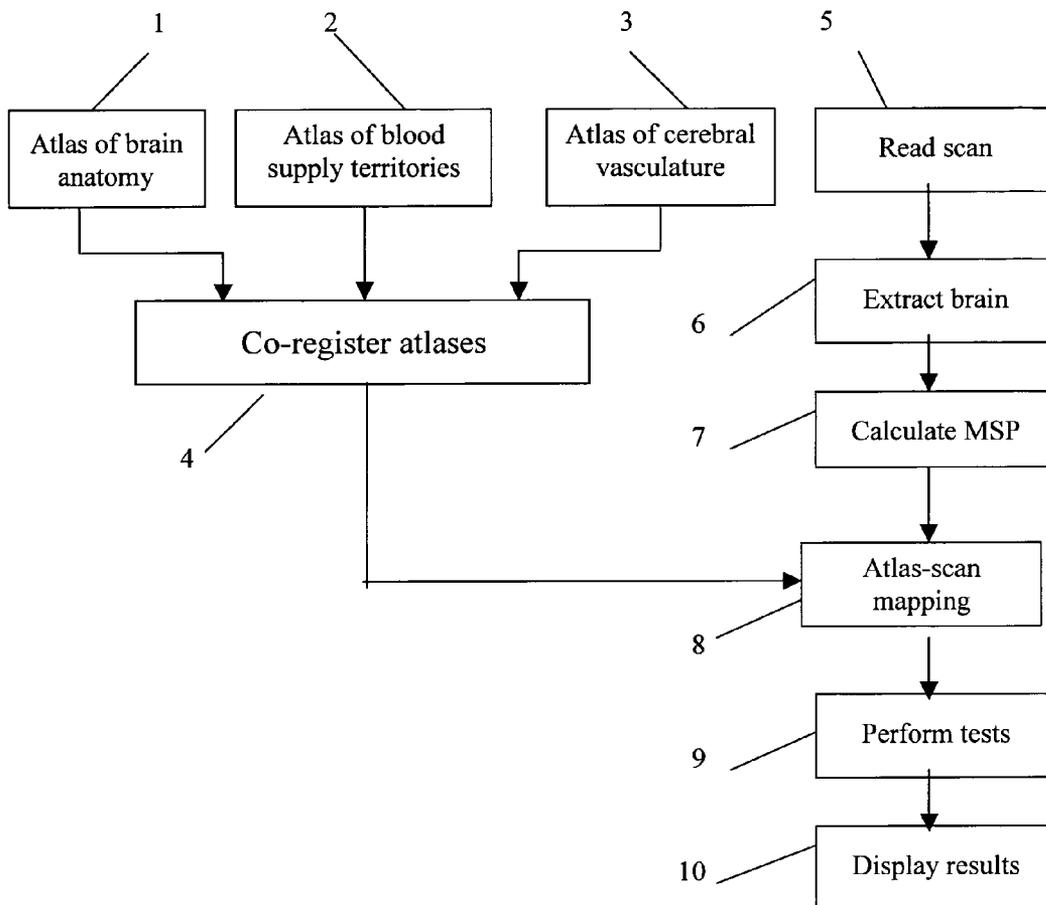
Fig. 1

Fig. 2

METHOD OF ANALYSING STROKE IMAGES

FIELD OF THE INVENTION

[0001] The present invention relates to a system, having method and apparatus aspects, for analysing brain scan images of a patient suspected of having a stroke, particularly a system which is of use in the emergency department (ED) of a hospital.

BACKGROUND OF THE INVENTION

[0002] The speed and efficiency of patient evaluation are critical factors in an emergency department. The key questions to be answered are whether 1) a patient has suffered a stroke or not, and if so whether 2) the stoke is ischemic or hemorrhagic.

SUMMARY OF THE INVENTION

[0003] The present invention aims to provide a new and useful methods and systems to determine from a scan whether a patient is suffering from a stroke.

[0004] In general terms the invention proposes that a plurality of brain atlases are co-registered, and mapped to a scan of a brain, and then the mapping is used to determine the presence of a stroke.

[0005] Preferred embodiments of the invention provide an accurate way of identifying strokes from patient brain scan data (such as CT or MRI data), and one which is particularly suitable for use in an emergency situation such as the emergency department of a hospital.

[0006] The invention may be expressed as a method of processing brain scans, as an apparatus for doing so, or as a computer program product storing software operable by a computer system to perform the method.

BRIEF DESCRIPTION OF THE EMBODIMENTS

[0007] An embodiment of the invention will now be described, for sake of example only, with reference to the accompanying drawings, in which:

[0008] FIG. 1 is a flow diagram of an embodiment of the invention; and

[0009] FIG. 2 is a flow diagram of the decision tree used in one of the steps of FIG. 1.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0010] Referring to FIG. 1, the flow diagram of an embodiment of the invention is shown. The embodiment is a method which may be performed by any conventional computer system, for example a computer system having a processor which is caused to follow the method by reading operating instructions from a computer program product, such as a recording medium storing the instructions.

[0011] The embodiment employs three input data sets which are respective brain atlases:

[0012]   an atlas of brain anatomy 1

[0013]   an atlas of cerebral vasculature 2

[0014]   and an atlas of blood supply territories 3.

[0015] Any existing brain atlases can be used for this purpose, for instance the atlases developed in our lab [1][2][3] [4]. The atlases are fully segmented and labeled, and their 3D version constructed.

[0016] In a first step 4 of the embodiment, all the atlases 1, 2, 3 are mutually co-registered using any existing techniques, for instance the FTT approach [5]. In an alternative form of the method, the co-registration process is performed in advance, and data representing the three atlases and their co-registration is input to the computer system, for example on the computer program product mentioned above.

[0017] The other input to the method is scan data 5 obtained by one or more scans of a particular patient.

[0018] In a step 6, the skull and scalp as well as any other extra-cerebral objects are removed from the scan. For this purpose, any existing method can be used, for instance that disclosed in [8] [10].

[0019] In a step 7, the midsagittal plane is extracted from the scan. For this purpose, any existing method can be used, for instance that disclosed in [6] [7]. In an alternative form of the embodiment, which improves accuracy, particularly, for the brains with a curved interhemispheric fissure, step 7 is replaced with a step of obtaining the midsagittal lines for each slice as calculated, for example in [11].

[0020] In a step 8, the mutually co-registered atlases obtained in step 4 are mapped into the scan. For this purpose any existing method can be used, for instance the FTT [5] or the statistical-based approach [9]. In addition, warping against ventricles can be used, particularly, for elder people with prominent vascular dilation. For ventricular extraction, the method described in [12] can be used. For atlas warping against the ventricles, the method described in [13] and [14] can be employed.

[0021] The mapping between the segmented and labeled brain atlases delineate regions of interest in the scan data. Any set of regions of interests with anatomical structures, vessels, and/or blood supply territories can be identified and used for analysis in the following steps of the embodiment.

[0022] In a step 9, a series of tests 91, 92, 93 applied to the output of step 9, in order to make reach a view in relation to the test. The decision tree is shown in FIG. 2.

[0023] When performing tests 91, 92, 93, all regions of interest identified using the atlases, or any subset of them, are compared. The comparison can be done by comparing corresponding identified regions of interest in the left and right hemispheres individually (i.e. one to one) or for any group of regions of the same patient, and/or by comparing the identified regions of interest to data obtained from normal patients.

[0024] The first test 91 is to determine whether the image contains asymmetry. The comparison can employ statistics of various kinds, in particular, the mean values and standard deviations (e.g. by obtaining values for these for each hemisphere, and declaring asymmetry if they differ by more than a predetermined threshold), as well as other standard statistical tests available in SPSS eg. [15]. More advanced techniques to capture asymmetry can also be applied including [16] [17] [18].

[0025] Statistical testing can be combined with image processing techniques to eliminate certain unwanted features from the image. In particular, low and high intensity thresholds can be set manually eliminating certain image regions (i.e. the ones outside the range between these thresholds), so that ventricles and/or the skull can be removed, optionally the images may be smoothed initially by performing median or anisotropic smoothing, and then the statistical tests can applied to the intensities within the defined range [19] [20] [21] [22] [23] [24] [25][26] [27]. In principle the smoothing step can be useful even if the thresholds are not employed.

[0026] The scan is considered normal if all the corresponding regions tested produce no significant difference. If any region varies significantly from that in the contralateral hemisphere (or normal), the scan is considered abnormal.

[0027] The second test **92** is to determine whether the asymmetry is due to a stroke, or instead to some other factor. There are several situations mimicking the stroke, and additional acquisitions and human intervention may be necessary to distinguish stroke from no stroke pathology [28], [29].

[0028] Sub-step **93** is discrimination between ischemic and hemorrhagic scans. This can be done based on intensity distribution [28] and [29]. In CT scans, hyperdensity signals hemorrahage, while hypointensity indicates ischemia. On T2 MR scans, this relationship is the reverse. Hounsfield Units (HU) can further be used for discrimination; for instance, HU range of 60-100 corresponds to blood.

[0029] In a final step **10**, the results of step **9** are output.

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1. An apparatus for identifying a stroke using brain scan data of a patient, the apparatus comprising a processor arranged to perform the steps of:

    forming a mapping between the scan data and a plurality of co-registered brain atlases;

    identifying a plurality of regions of interest in the scan data using the co-registered brain atlases; and

    testing one or more of the identified regions of interest, thereby identifying the presence of a stroke.

2. An apparatus according to claim 1 in which the co-registered brain atlases comprise one or more of:

    an atlas of brain anatomy;

    an atlas of cerebral vasculature; and

    an atlas of blood supply territories.

3. An apparatus according to claim 1 in which the processor is arranged to co-register the brain atlases.

4. An apparatus according to claim 1 in which said testing comprises identifying whether an asymmetry exists between corresponding regions of interest in different hemispheres of the brain, and, if so, identify abnormality.

5. An apparatus according to claim 4 in which said testing further comprises identifying the presence of a stroke.

6. An apparatus according to claim 5 in which said testing further comprises identifying whether the stroke is ischemic or hemorrhagic.

7. An apparatus according to claim 1 in which, prior forming said mapping, the brain scan is subject to a process for extracting the portions of the image which represent background.

8. An apparatus according to claim 1 in which, prior to forming said mapping, a mid-sagittal plane is extracted, the mid-sagittal plane being used in the mapping process.

9. A method for identifying a stroke using brain scan data of a patient, the method comprising:

    forming a mapping between the scan data and a plurality of co-registered brain atlases;

    identifying a plurality of regions of interest in the scan data using the co-registered brain atlases; and

    testing one or more of the identified regions of interest, thereby identifying the presence of a stroke.

10. A method according to claim 9 in which the co-registered brain atlases comprise one or more of:

    an atlas of brain anatomy;

    an atlas of cerebral vasculature; and

    an atlas of blood supply territories.

11. A method according to claim 9 further comprising co-registering the brain atlases.

12. A method according claim 9 in which said testing comprises identifying whether an asymmetry exists between corresponding regions of interest in different hemispheres of the brain, and, if so, identifying abnormality

13. A method according to claim 12 in which said testing further comprises identifying the presence of a stroke.

14. A method according to claim 13 in which said testing further comprises identifying whether the stroke is ischemic or hemorrhagic.

15. A method according to claim 9 in which, prior forming said mapping, the brain scan is subject to a process for extracting the portions of the image which represent background.

16. A method according to claim 9 in which, prior to forming said mapping, a mid-sagittal plane is extracted, the mid-sagittal plane being used in said step of forming said mapping.

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