Web-based interactive 2D/3D medical image processing and visualization software

CT画像を表示するためのソフトウェア

撮影 画像表示

Abstract

There are many medical image processing software tools available for research and diagnosis purposes.

研究・診断目的で利用可能な医療画像処理ソフトウェアツールがたくさんある。

However, most of these tools are available only as local applications.

しかしながら、それらツールの大半がローカルアプリケーションとしてだけで利用可能だ。

This limits the accessibility of the software to a specific machine, and thus the data and processing power of that application are not available to other workstations.

local applicationであること.

この特定の機械へのソフトウェアのアクセス制限により、データとアプリケーションの処理能力は他のワークステーションに利用できない。

Further, there are operating system and processing power limitations which prevent such applications from running on every type of workstation.

さらに、ワークステーションのあらゆる型で動作を妨げる、OS と処理能力のアプリケーションのような制限がある。

By developing web-based tools, it is possible for users to access the medical image processing functionalities wherever the internet is available.

Web ベースのツールの開発により、インターネットが利用可能な場所なら、ユーザーは医療画像を処理する機能にアクセス可能だ。

In this paper, we introduce a pure web-based, interactive, extendable, 2D and 3D medical image processing and visualization application that requires no client installation.

この論文では、クライアントのインストールを必要としない、純粋な Web ベースで、インタラクティブで、拡張可能で 2D や 3D な医療画像処理と可視化アプリケーションを紹介する。

Our software uses a four-layered design consisting of an algorithm layer, web-user-interface layer, server communication layer, and wrapper layer.

我々のソフトウェアはアルゴリズム層・Web ユーザーインターフェース層・サーバー通信層・ラッパー層から成る 4 層デザインを使用する。

To compete with extendibility of the current local medical image processing software, each layer is highly

independent of other layers.

現在のローカル医療画像処理ソフトウェアの拡張性と競合するため、それぞれの層は他の層と高く独立している。

A wide range of medical image preprocessing, registration, and segmentation methods are implemented using open source libraries.

広範囲の医療画像処理、登録、分割方式はオープンソースライブラリの利用を実行される。

Desktop-like user interaction is provided by using AJAX technology in the web-user-interface.

デスクトップのようなユーザーとの対話処理は Web ユーザーインターフェースの AJAX 技術を利用して提供される。

For the visualization functionality of the software, the VRML standard is used to provide 3D features over the web.

ソフトウェアの可視化機能のため、VRML スタンダードは web 上で 3D 特徴を提供するために使用される。

↳X3D → ?

Integration of these technologies has allowed implementation of our purely web-based software with high functionality without requiring powerful computational resources in the client side.

これら技術の統合はクライアント側の強力な計算資源の要求なしに、高い機能性で私たちの Web ベースのソフトウェアの実行を許している。

The user-interface is designed such that the users can select appropriate parameters for practical research and clinical studies.

ユーザーインターフェースは実用化研究や臨床研究のためユーザーが適切なパラメーターを選択できるようにデザインされた。

Introduction

Today medical imaging plays an important role in speed and quality of medical diagnosis.

今日、医療画像は医療診断のスピードと質において重要な役割を担っている。

Conventional radiology is prone to problems such as losing films, accessing with delay, spending considerable amount of time and cost to copy and archive the film, and limited application of image processing methods [1].

従来の放射線医学では、フィルムの消失、遅れたアクセス、フィルムをコピーして保管するためのかなりの時間と費用の費やし、画像処理方法の限定された適用などの問題が生じやすい[1]。

Towards the end of the 1970s, digital methods for radiology which use digital image representation became

widespread [2].
1970 年代の終わりに向けて、デジタル画像表現を使用する放射線医学のためのデジタル手法が広く普及した[2]。

In digital radiology, images are either acquired digitally or converted from analog to digital.
デジタル放射線医学では、画像はデジタル方式で取得されるか、アナログからデジタルに変換される。
In either case, this digital input necessitates strong medical image processing tools to process them.
いずれの場合も、このデジタル入力は、それらを処理するために強力な医療画像処理ツールを必要とする。

There are several common functionalities for any medical image processing system.
どの医療画像処理システムにも、いくつかの共通の機能がある。
Digital images should be processed, saved, and retrieved easily and quickly using the software.
デジタル画像は、ソフトウェアを使用して簡単かつ速く処理、保存、検索される必要がある。
They must compromise their characteristics in terms of reading, writing, and representing different image formats, applying various automatic analysis methods on the images in 2D and 3D, and applying new image processing methods to accurately segment and visualize the data [3,4].
これらは、さまざまな画像形式の読み書き、表現、2D および 3D 画像のさまざまな自動分析方法の適用、データを正確にセグメント化して視覚化するための新しい画像処理方法を適用するという点で、特性を妥協する必要がある。
These functionalities are necessary for computer assisted diagnosis and therapy.
これらの機能は、コンピュータ支援による診断と治療に必要だ。

Various software for representing, processing, and visualization of medical images have been designed [5–30] including 3D-Doctor, eFilm Workstation, PACSPlus Viewer, EigenTool, MEDAL, Imaris, Caret, Analyze, Vitrea2-Fusion7D, Medx, 3DVIEWNIX, 3D Slicer, Julius, OsiriX, BrainSuite, MIPAV, and MRIcro.
3D-Doctor、eFilm Workstation、PACSPlus Viewer、EigenTool、MEDAL、Imaris、Caret、Analyze、Vitrea2-Fusion7D、Medx、3DVIEWNIX、3D Slicer、Julius、OsiriX、BrainSuite、MIPAV、MRIcro など医療画像の表示、処理、視覚化のためのさまざまなソフトウェアが設計されている。
Some of these software tools work as image viewers supporting a variety of image formats such as Dicom and Analyze [6,7].
これらのソフトウェアツールの一部は、Dicom や Analyze [6,7]のようなさまざまなイメージフォーマットをサポートするイメージビューアとして機能する。

Other tools also provide processing and visualization functionalities such as noise suppression, registration, applying conventional segmentation methods, analyzing images for diagnosis purposes, and representing 2D and 3D data using regular visualization methods.

その他のツールもまた、ノイズ抑制、登録、従来のセグメンテーション手法の適用、診断目的の画像の解析、および通常の視覚化手法を使用した 2D および 3D データの表現といった処理および視覚化機能を提供する。

It should be noted that not all of these features are implemented in all of the software tools.

これらの機能のすべてがすべてのソフトウェアツールで実装されているわけではない。

Usually, each tool is developed such that it is suitable for some specific applications.

通常、各ツールは特定のアプリケーションに適したものになるように開発されている。

For example, 3D-Doctor is developed for processing and visualization, while Vitera-Fusion7D is developed for image registration.

例えば、3D-Doctor は処理と視覚化のために開発されているのに対して、Vitera-Fusion7D は画像登録のために開発されている。

Another important aspect of medical image processing software is the extendibility of the software.

医療画像処理ソフトウェアのもう 1 つの重要な側面は、ソフトウェアの拡張性だ。

As new processing algorithms are developed which are more robust, powerful, and suitable for specific applications, extensions of the software to include these algorithms are inevitable.

より堅牢で強力で、特定のアプリケーションに適した新しい処理アルゴリズムが開発されるにつれて、これらのアルゴリズムを含むソフトウェアの拡張は避けられない。

Among these existing tools, most are not extendible.

これらの既存のツールの中でも、ほとんどが拡張可能ではない。

3D Slicer is unique as it is open source and the user may add new processing routines to it.

3D Slicer はオープンソースなのでユニークで、ユーザーは新しい処理ルーチンを追加することができる。

This feature has made this software more practical and appropriate for academic and research applications.

この特徴により、このソフトウェアは、学術および研究アプリケーションに、より実用的かつ適切になった。

An important issue in medical imaging is the ability to access the processed data quickly and easily.

医療画像の重要な問題は、処理されたデータにすばやく簡単にアクセスできることだ。

Web-based soft- ware tools are becoming a popular solution [22–30].

Web ベースのソフトウェアツールは、一般的なソリューションになりつつある[22-30]。

One such example is the Web-Based Multi-layer Visualization System (WBMVS) [30].

このような例の 1 つに Web-Based Multi-layer Visualization System（WBMVS）[30]がある。

However, these web applications either suffer from poor user-interface (UI) functionalities or require the user to install ActiveX or Java Applet components.

ただし、これらの Web アプリケーションは、ユーザーインターフェイス（UI）の機能が不十分であるか、ユーザーに ActiveX または Java アプレットコンポーネントをインストールする必要がある。

This causes the loss of many advantages of web-based applications.

これにより、Web ベースのアプリケーションの多くの利点が失われる。

Using a web application, by centralized storage of data and availability of the software on different platforms, physicians can easily access patient's data from any computer station, regardless of relative processing power or operating system.

Web アプリケーションを使用することで、データを集中的に格納し、異なるプラットフォーム上でのソフトウェアの可用性を発揮できるため、医師は相対的な処理能力やオペレーティングシステムに関係なく、どのコンピュータステーションからでも患者のデータに簡単にアクセスできる。

There are some fundamental advantages in using web-based medical software.

Web ベースの医療用ソフトウェアの使用にはいくつかの基本的な利点がある。

Because of rapid changes in medical tools, the ability to update the software without interrupting the users and modifying their hardware and local software is necessary.

医療ツールの急速な変化のために、ユーザーを中断せずにハードウェアとローカルソフトウェアを変更することなくソフトウェアを更新する能力が必要だ。

Further, there are many complex processing algorithms that require large memory and computational resources that may not be available on many client machines [30].

さらに、多くのクライアントマシンでは利用できない大量のメモリと計算リソースを必要とする複雑な処理アルゴリズムが多数存在する[30]。

By centralizing processing power and using server machines with large computational resources, it is possible for the client machine to work as a simple terminal.

処理能力を集中化し、大きな計算リソースを持つサーバー・マシンを使用することにより、クライアントマシンは単純な端末として機能することができる。

The acquired data can be saved on the server side and users can access them via the network.

取得したデータはサーバー側に保存することができ、ユーザーはネットワーク経由でアクセスすること

ができる。

The importance of this structure is particularly evident in emergency conditions where quick decisions should be made in locations where resources are limited, such as outside of the hospital or in the field.

この構造の重要性は、病院の外や現場など、限られた場所で迅速な決定が行われるような緊急時に特に顕著だ。

Physicians can access and process the patient's medical data quickly and easily using the proposed web-bases medical imaging software.

医師は、提案されたウェブベースの医療画像ソフトウェアを使用して、迅速かつ容易に患者の医療データにアクセスし、処理することができる。

Although there are many Picture Archiving and Communication Systems (PACS) available for centralized data access, most of these systems are designed for Local Area Network (LAN) access, not for internet use.

集中データアクセスのために利用できる PACS（Picture Archiving and Commution System）は数多くありますが、これらのシステムのほとんどは、インターネットではなくローカルエリアネットワーク（LAN）アクセス用に設計されている。

Also, all current web-based PACS systems are based on ActiveX or Java Applet, which are not considered pure web-based solutions, because they impose pre-installation requisites and are not platform inde- pendent.

また、現在の Web ベースの PACS システムはすべて、ActiveX や Java アプレットをベースにしています。これらのシステムは、プリインストール要件を満たし、プラットフォームに依存しないため、純粋な Web ベースのソリューションとは見なされません。

In addition, current PACS solutions normally do not perform algorithmic processing on the image and simply serve as image viewers.

さらに、現在の PACS ソリューションは、通常、画像に対してアルゴリズム処理を実行せず、単に画像ビューアとして機能する。

In this paper, we introduce a pure web-based, interactive, extendable, 3D and 2D medical image processing and visualization application, which requires no client installation.

本論文では、クライアント側のインストールを必要としない、Web ベースのインタラクティブで拡張可能な 3D および 2D の医療画像処理およびビジュアライゼーションアプリケーションを紹介する。

Our software uses a four-layered design consisting of an algorithm layer, web-UI layer, server communication layer, and wrapper layer.

我々のソフトウェアは、アルゴリズム層、Web-UI 層、サーバー通信層、およびラップ層からなる 4 層設

計を使用している。

To compete with extendibility of the current local medical image processing software, each layer is highly independent of the other layers.

現行のローカル医療画像処理ソフトウェアの拡張性と競合するために、各層は他の層とは独立している。

A wide range of medical image preprocessing, registration, and segmentation methods are implemented using open source libraries.

幅広い医療画像の前処理、登録、およびセグメンテーションの方法は、オープンソースライブラリを使用して実装されている。

Desktop-like user interaction is provided by using AJAX technology in the Web- UI.

Web UI で AJAX テクノロジを使用することによって、デスクトップのようなユーザー対話が提供される。

For the visualization functionality of the software, the VRML standard is used to provide 3D features over the web.

ソフトウェアの視覚化機能のために、VRML 標準を使用して Web 上に 3D 機能を提供する。

Integration of these technologies has allowed implementation of our purely web-based software with high functionality without requiring powerful computational resources in the client side.

これらのテクノロジを統合することで、クライアント側で強力な計算リソースを必要とせずに、純粋に高機能な Web ベースのソフトウェアを実装することができた。

The UI is designed such that the users can select appropriate parameters for practical research and clinical studies.

UI は、ユーザーが実際の研究や臨床研究に適したパラメータを選択できるように設計されている。

The organization of the rest of the paper is as follows.

残りの論文の構成は次のとおりだ。

In Section 2, we describe design constrains and technology choices.

第 2 節では、設計制約と技術選択について述べる。

Section 3 describes our software architecture.

セクション 3 では、当社のソフトウェアアーキテクチャについて説明する。

Section 4 describes the user-interface of the software.

セクション 4 では、ソフトウェアのユーザーインターフェイスについて説明する。

Section 5 com- pares our software with software tools developed previously for representing, processing, and visualization of medical images.

5 章では、私たちのソフトウェアを、医療画像の表示、処理、視覚化のために以前に開発されたソフトウェアツールと比較する。

Finally, in the Section 6, we present discussion and conclusions.

最後に、第 6 章で議論と結論を示す。

COMPUTER METHODS AND PROGRAMS IN BIOMEDICINE 98 (2010) 172–182

ELSEVIER

journal homepage: www.intl.elsevierhealth.com/journals/cmpb

Web-based interactive 2D/3D medical image processing and visualization software

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ARTICLE INFO

Article history:
Received 6 May 2009
Received in revised form
16 November 2009
Accepted 19 November 2009

Keywords:
Web-based software tools
2D and 3D processing and visualization
Medical imaging and analysis

ABSTRACT

There are many medical image processing software tools available for research and diagnosis purposes. However, most of these tools are available only as local applications. This limits the accessibility of the software to a specific machine, and thus the data and processing power of that application are not available to other workstations. Further, there are operating system and processing power limitations which prevent such applications from running on every type of workstation. By developing web-based tools, it is possible for users to access the medical image processing functionalities wherever the internet is available. In this paper, we introduce a pure web-based, interactive, extendable, 2D and 3D medical image processing and visualization application that requires no client installation. Our software uses a four-layered design consisting of an algorithm layer, web-user-interface layer, server communication layer, and wrapper layer. To compete with extendibility of the current local medical image processing software, each layer is highly independent of other layers. A wide range of medical image preprocessing, registration, and segmentation methods are implemented using open source libraries. Desktop-like user interaction is provided by using AJAX technology in the web-user-interface. For the visualization functionality of the software, the VRML standard is used to provide 3D features over the web. Integration of these technologies has allowed implementation of our purely web-based software with high functionality without requiring powerful computational resources in the client side. The user-interface is designed such that the users can select appropriate parameters for practical research and clinical studies.

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0169-2607/$ – see front matter
doi:10.1016/j.cmpb.2009.11.012

1. Introduction

Today medical imaging plays an important role in speed and quality of medical diagnosis. Conventional radiology is prone to problems such as losing films, accessing with delay, spending considerable amount of time and cost to copy and archive the film, and limited application of image processing methods [1]. Towards the end of the 1970s, digital methods for radiology which use digital image representation became widespread [2]. In digital radiology, images are either acquired digitally or converted from analog to digital. In either case, this digital input necessitates strong medical image processing tools to process them.

There are several common functionalities for any medical image processing system. Digital images should be processed, saved, and retrieved easily and quickly using the software. They must compromise their characteristics in terms of reading, writing, and representing different image formats, applying various automatic analysis methods on the images in 2D and 3D, and applying new image processing methods to accurately segment and visualize the data [3,4]. These functionalities are necessary for computer assisted diagnosis and therapy.

Various software for representing, processing, and visualization of medical images have been designed [5–30] including 3D-Doctor, eFilm Workstation, PACSPlus Viewer, EigenTool, MEDAL, Imaris, Caret, Analyze, Vitrea2-Fusion7D, Medx, 3DVIEWNIX, 3D Slicer, Julius, OsiriX, BrainSuite, MIPAV, and MRIcro. Some of these software tools work as image viewers supporting a variety of image formats such as Dicom and Analyze [6,7]. Other tools also provide processing and visualization functionalities such as noise suppression, registration, applying conventional segmentation methods, analyzing images for diagnosis purposes, and representing 2D and 3D data using regular visualization methods. It should be noted that not all of these features are implemented in all of the software tools. Usually, each tool is developed such that it is suitable for some specific applications. For example, 3D-Doctor is developed for processing and visualization, while Vitera-Fusion7D is developed for image registration.

Another important aspect of medical image processing software is the extendibility of the software. As new processing algorithms are developed which are more robust, powerful, and suitable for specific applications, extensions of the software to include these algorithms are inevitable. Among these existing tools, most are not extendible. 3D Slicer is unique as it is open source and the user may add new processing routines to it. This feature has made this software more practical and appropriate for academic and research applications.

An important issue in medical imaging is the ability to access the processed data quickly and easily. Web-based software tools are becoming a popular solution [22–30]. One such example is the Web-Based Multi-layer Visualization System (WBMVS) [30]. However, these web applications either suffer from poor user-interface (UI) functionalities or require the user to install ActiveX or Java Applet components. This causes the loss of many advantages of web-based applications. Using a web application, by centralized storage of data and availability of the software on different platforms, physicians can easily access patient's data from any computer station, regardless of relative processing power or operating system.

There are some fundamental advantages in using web-based medical software. Because of rapid changes in medical tools, the ability to update the software without interrupting the users and modifying their hardware and local software is necessary. Further, there are many complex processing algorithms that require large memory and computational resources that may not be available on many client machines [30]. By centralizing processing power and using server machines with large computational resources, it is possible for the client machine to work as a simple terminal. The acquired data can be saved on the server side and users can access them via the network. The importance of this structure is particularly evident in emergency conditions where quick decisions should be made in locations where resources are limited, such as outside of the hospital or in the field. Physicians can access and process the patient's medical data quickly and easily using the proposed web-bases medical imaging software.

Although there are many Picture Archiving and Communication Systems (PACS) available for centralized data access, most of these systems are designed for Local Area Network (LAN) access, not for internet use. Also, all current web-based PACS systems are based on ActiveX or Java Applet, which are not considered pure web-based solutions, because they impose pre-installation requisites and are not platform independent. In addition, current PACS solutions normally do not perform algorithmic processing on the image and simply serve as image viewers.

In this paper, we introduce a pure web-based, interactive, extendable, 3D and 2D medical image processing and visualization application, which requires no client installation. Our software uses a four-layered design consisting of an algorithm layer, web-UI layer, server communication layer, and wrapper layer. To compete with extendibility of the current local medical image processing software, each layer is highly independent of the other layers. A wide range of medical image preprocessing, registration, and segmentation methods are implemented using open source libraries. Desktop-like user interaction is provided by using AJAX technology in the Web-UI. For the visualization functionality of the software, the VRML standard is used to provide 3D features over the web. Integration of these technologies has allowed implementation of our purely web-based software with high functionality without requiring powerful computational resources in the client side. The UI is designed such that the users can select appropriate parameters for practical research and clinical studies.

The organization of the rest of the paper is as follows. In Section 2, we describe design constrains and technology choices. Section 3 describes our software architecture. Section 4 describes the user-interface of the software. Section 5 compares our software with software tools developed previously for representing, processing, and visualization of medical images. Finally, in the Section 6, we present discussion and conclusions.