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- CONTENTS-

JSMBE-MBI2017-01

Automated segmentation of renal arterial branches from abdominal contrast enhanced CT images using Convolutional Neural Network and knowledge of vessel anatomy: A comparison of network structures

Yuki Suzuki (NAIST, Osaka University), Mariko Ono, Yuta Hiasa (NAIST), Masatoshi Hori (Osaka University), Yoshito Otake (NAIST), Noriyuki Tomiyama (Osaka University), Yoshinobu Sato(NAIST)

JSMBE-MBI2017-02

Synthetic Biosignal Generation Based on Generative Adversarial Networks

Shota Harada, Hideaki Hayashi, Seiichi Uchida (Kyushu University)

JSMBE-MBI2017-03

[Invited Lecture] The role of machine learning/architectural intelligence in computer-aided diagnosis systems

Mitsutaka Nemoto (Kindai University)

JSMBE-MBI2017-04

Kinematic analysis of forearm rotation including subluxation by 2D-3D registration using biplane fluoroscopy.

Yusuke Tenma, Yuta Hiasa, Yoshito Otake (NAIST), Shingo Abe, Tsuyoshi Murase (Osaka University), Yoshinobu Sato (NAIST)

JSMBE-MBI2017-05

Improvement of athlete performance and injury prevention research using IoT

Hiromi Takahata, Issei Ogasawara, Takuya Magome, Akira Uchiyama, Shouji Konda, Teruki Yokoyama, Yuri Kitamura, Ken Nakata (Osaka University)

JSMBE-MBI2017-06

Reconstruction of 3-Dimensional Rotator Cuff Tear Shape using Magnetic Resonance Images

Kazuki Ishiro, Kento Morita, Manabu Nii (University of Hyogo), Tomoyuki Muto, Hiroshi Tanaka, Hiroaki Inui (Nobuhara Hospital), Syoji Kobashi (University of Hyogo), Katsuya Nobuhara (Nobuhara Hospital)

JSMBE-MBI2017-07

Estimation of muscle fiber direction from 3D ultrasound image with mechanical linear guide system and reconstruction of 4D muscle motion

Norio Fukuda, Tokumi Sano, Yoshito Otake (NAIST), Shingo Abe, Shoji Konda (Osaka University), Yoshinobu Sato (NAIST)

JSMBE-MBI2017-08

A New Image-based Method for Vortex Structure Analysis of the Developing Human Fetal Heart

Ryo Haraguchi (University of Hyogo), Saori Nishitani, Hirohiko Imai, Tetsuya Takakuwa (Kyoto University)

—目次—

JSMBE-MBI2017-01

畳み込みニューラルネットワークと解剖学的知識を用いた腹部造影 CT 画像からの腎動脈枝の自動抽出－ネットワーク構造の比較－

鈴木 裕紀（奈良先端科学技術大学院大学，大阪大学），小野 真理子，日朝 祐太（奈良先端科学技術大学院大学），堀 雅敏（大阪大学），大竹 義人（奈良先端科学技術大学院大学），富山 憲幸（大阪大学），佐藤 嘉伸（奈良先端科学技術大学院大学）

JSMBE-MBI2017-02

Generative Adversarial Networks に基づく人工生体信号生成

原田 翔太, Hideaki Hayashi, Seiichi Uchida（九州大学）

JSMBE-MBI2017-03

[招待講演] 画像診断支援システムにおける機械学習・人工知能の役割

根本 充貴（近畿大学）

JSMBE-MBI2017-04

2 方向 X 線透視動画像を用いた 2D-3D レジストレーションによる亜脱臼動作を含む前腕回旋動態解析

天満 勇介，日朝 祐太，大竹 義人（奈良先端科学技術大学院大学），阿部 真悟，村瀬 剛（大阪大学），佐藤 嘉伸（奈良先端科学技術大学院大学）

JSMBE-MBI2017-05

IoT を活用したアスリートパフォーマンス向上と障害予防研究

高畑 裕美，小笠原 一生，馬込 卓弥，内山 彰，近田 彰司，横山 光樹，橋詰 謙，喜多村 祐里，中田 研（大阪大学）

JSMBE-MBI2017-06

MR 画像を用いた肩腱板断裂 3 次元形状の再構築

井城 一輝，盛田 健人，新居 学（兵庫県立大学），無藤 智之，田中 洋，乾 浩明（信原病院），小橋 昌司（兵庫県立大学），信原 克哉（信原病院）

JSMBE-MBI2017-07

機械式リニアガイドによる 3 次元超音波画像を用いた筋繊維方向推定および筋肉の 4 次元動態復元

福田 紀生，佐野 徳美，大竹 義人（奈良先端科学技術大学院大学），阿部 慎吾，近田彰治（大阪大学），佐藤 嘉伸（奈良先端科学技術大学院大学）

JSMBE-MBI2017-08

ヒト胎児心臓心尖部における渦構造の画像解析手法の提案

原口 亮（兵庫県立大学），西谷 早織，今井 宏彦，高桑 徹也（京都大学）

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Automated segmentation of renal arterial branches from abdominal contrast enhanced CT images using Convolutional Neural Network and knowledge of vessel anatomy: A comparison of network structures

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Abstract

To make a surgical plan for surgeries such as organ transplantation or resection, it is necessary for medical doctors to understand vascular structure and its positional relationship between organs. To understand vascular structure in abdominal region, contrast enhanced CT images are widely used, but complex structure of abdominal vessels makes it hard and laborious. For this reason, it is valuable to automatically extract the vascular region from 3D-CT images with a computer to support doctors.

Line enhancement filtering has been widely used for the segmentation of tubular structure. While line enhancement filtering works effectively for tubular structure with certain radius and curvature, it tends to fail to enhance thin vessel with small radius. Convolutional Neural Network (CNN) has been making huge success in computer vision, and medical and biological imaging. In this paper, we propose automated segmentation of renal arterial branches using CNN.

In the experiment using 3D-CT images and manually labelled renal arterial regions, existing method using line filter and proposed method using CNN were compared.

Keywords: segmentation, convolutional neural network

Synthetic Biosignal Generation Based on Generative Adversarial Networks

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Abstract

Biosignals strongly reflect human internal states. In particular, the human body including diseases can cause visible changes in the patterns of biosignals. Disease can therefore be detected by classifying patterns of biosignals. Many studies on classification of biosignals using machine learning techniques including deep learning have been reported. Thanks to deep learning, some studies achieved drastic increase in classification accuracy. One problem with deep learning is that a large amount of training data is required to obtain enough accuracy. However, the number of training data is often limited in the real-world biosignal classification problems.

In this study, we propose a time-series data generation method based on Generative Adversarial Networks (GANs) to increase the number of training data of biosignals. GANs are deep neural network frameworks contained of two neural networks. In the proposed method, each neural network is developed based on a long short-term memories (LSTM) for its hidden layers. Thereby allowing the adaptation of GANs framework to time-series data generation.

In the experiments, we confirmed the capability of the proposed method for generating biosignals. To show the effectiveness of the proposed method, the results using the proposed method and the existing three data augmentation methods were compared.

Keywords: Neural networks in biosignal classification, Biosignal data augmentation.

The Role of Machine Learning / Architectural Intelligence in Computer-Aided Diagnosis Systems

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Abstract

Recently, architectural intelligence (AI) is paid the most attention. We introduce the properties of AI (e.g., what AI can/cannot do). We also introduce some application examples of AI for medical image analysis and computer-aided diagnosis/detection.

Keywords: Machine learning, Architectural Intelligence (AI), Computer-Aided Diagnosis (CAD/CADx), Computer-Aided Detection (CADe).

Kinematic analysis of forearm rotation including subluxation by 2D-3D registration using biplane fluoroscopy

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Abstract

In orthopedic surgery, the quantitative kinematic analysis of skeletal structures is important to improve accuracy of the patient-specific treatment. In case of the forearm, 3D motion analysis of pronation and supination is important for diagnosis and treatment planning. Previous studies analyzed the 3D rotation axis during the movement between maximum pronation and maximum supination using CTs at three postures [1]. In order to understand the movement of the forearm in more detail in a clinical routine, a method which allows 3D motion analysis with high temporal resolution while keeping the radiation dose at the level comparable to the conventional x-ray imaging is preferable. Our specific goal in this study is to analyze the detailed mechanism of instability of the elbow and wrist joints including a quick movement. For this purpose, we propose a 2D-3D registration method using a calibrated biplanar dynamic fluoroscopy and a CT image. The method follows that of Otake et al [2] which optimizes the rigid transformation parameters of multiple bones by maximizing the similarity between the fluoroscopy and digitally reconstructed radiograph (DRR).

In this paper, we report three evaluation experiments which used x-ray images of (1) a phantom model of the bones with soft tissue, (2) a healthy volunteer, and (3) a patient acquired in a clinical protocol. Through these experiments, we evaluated the accuracy of the proposed methods and analyzed the kinematics of forearm rotation including a quick movement. Fig.1 shows the 3D kinematics estimated from the clinical fluoroscopy images. Fig. 2 shows the translation of the radius with respect to the coordinate system of the humerus bone. The proposed method was able to obtain the kinematics of the forearm in the case of subluxation owing to the high temporal resolution of the x-ray fluoroscopy.

(a) (b) (c) (d)

Fig.1 Example visualization of the analyzed 3D kinematics using the clinical fluoroscopy images. (a) lateral image (LAT), (b) anteroposterior image (AP), (c) and (d) LAT and AP images overlaid with the estimated 3D bone position.

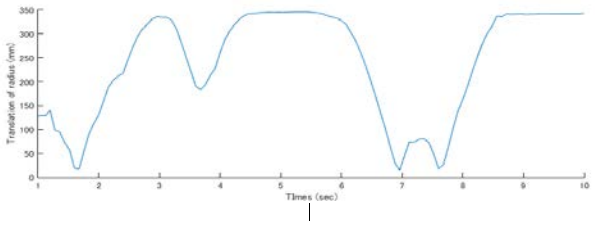

Fig.2 The translation of radius with respect to the coordinate system of the humerus.

Keywords: kinematic analysis, forearm, 2D-3D registration, x-ray fluoroscopy

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Improvement of athlete performance and injury prevention research using IoT (IoT を活用したアスリートパフォーマンス向上と障害予防研究)

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Abstract
Promote the use of IoT to realize support for strengthening players for the purpose of improving Japanese sports competitiveness. Then, Cooperation is achieved with Japan sports promotion center (JSC), a national sports science center (JISS), the university where cooperation cooperates and a private enterprise. And different field fusion related to a sport (medicine, nutrition, information science, engineering and physical education) is promoted. We will establish "sports research all-japan research base" to conduct comprehensive sports related research. In this method, performance index of athlete is derived by utilizing plural sensing devices. Also, by measuring the changes in body weight in detail, we will also detect the sign of injury.
That programs a production course of the sports medical department science researcher who contributes to the world and does leader education of human resources of the sports medical department science field.

Keywords: Sports Medical Science, Sports IoT, Injury prevention

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Reconstruction of 3-Dimensional Rotator Cuff Tear Shape using Magnetic Resonance Images

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Abstract

The shoulder rotator cuff is a group of muscle tendons that includes supraspinatus, infraspinatus, subscapularis and teres minor. Tears of the rotator cuff are a common musculoskeletal injury in which the tendons are pulled off from their insertion on the humerus bone. This is known as rotator cuff tear (RCT). In serious case, the patients have to undergo surgical operation because it often causes acute pain and limits the movement of the shoulder. According to location, direction and size of RCT, the orthopedic surgeon select the operative method. Therefore, the diagnosis of RCT shape is very important for its treatment. Currently, magnetic resonance (MR) images are used to diagnose RCT shapes. However, it is not easy to determine RCT shape because MR images have a spacing between slices. In this study, we propose a method to reconstruction of 3-Dimensional RCT shape from MR images. It is aimed to support the diagnosis. Firstly, we have extracted three regions, humeral head, normal cuff and torn cuff, from MR images. Secondly, we have calculated implicit function based on these regions. Then, the function values of slice gap have been interpolated by the radial based function. Finally, we have obtained 3-D RCT shape by rendering the function. The proposed method has been applied in RCT patients' MR images. We have obtained smooth and natural 3-D RCT shapes through our proposed method. And then, we have diagnosed RCT type and size by using the 3-D shapes. In the result, the accuracy diagnosed by 3-D shapes is higher than using only MR images. The result shows that the proposed method successfully assists orthopedic surgeons in their treatment of RCT.

Keywords: rotator cuff tear, magnetic resonance imaging, 3-dimensional shape, implicit function.

Estimation of muscle fiber direction from 3D ultrasound image with mechanical linear guide system and reconstruction of 4D muscle motion

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Abstract

Analysis of three-dimensional structure of muscles and its movement is important for sports science and rehabilitation. A dynamic-2D ultrasound image is widely used for analyzing muscle function because the ultrasound images have high temporal resolution and high contrast of muscle fascicles [1]. However, there is no information of outside the scanning plane so the three-dimensional structure cannot be acquired. On the other hand, a common 3D ultrasound image has low temporal resolution and limited field-of-view (FOV). Therefore our goal is to reconstruct a dynamic 3D ultrasound image which has high temporal resolution and large FOV by combining the dynamic 2D ultrasound image and static large 3D ultrasound image. In this study, we developed a mechanical guide system for reconstructing large 3D ultrasound volume with high accuracy. We create dynamic-3D volume by integration of static-3D and dynamic-2D for analyzing muscle function with the mechanical guide system. We used the slice-to-volume non-rigid registration [2] to identify deformation near the 2D plane and reconstruct dynamic-3D data by interpolating the 2D planes. In the experiments, we compared the reconstruction accuracy of the freehand system and the proposed linear guide system using a block phantom and we validated the accuracy of slice-to-volume non-rigid registration by simulation and real image.

Keywords: Ultrasound, Muscle function analysis, Muscle fiber analysis.

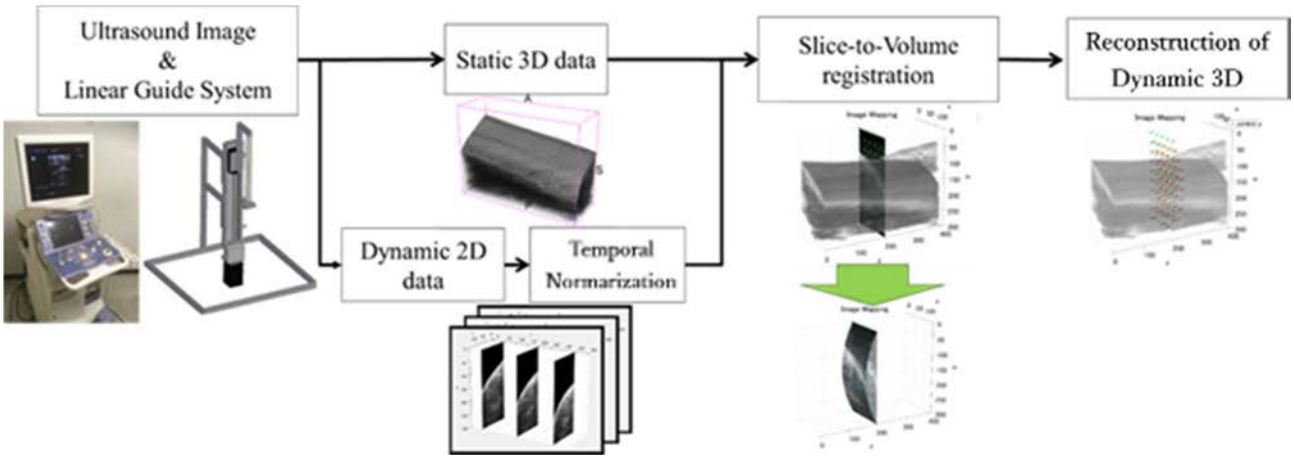

Figure 1. Overview of the reconstruction method of a dynamic 3D ultrasound image with a linear guide scanning system.

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A New Image-based Method for Vortex Structure Analysis of the Developing Human Fetal Heart

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Abstract

We have developed a new image-based method for vortex structure analysis of the human fetal heart. It is well known that human heart has a helical structure of its ventricular wall; however, we currently lack an understanding of how the detailed vortex structure of its heart apex. In this preliminary study, we have attempted a quantitative analysis of the myocardial architecture of *ex vivo* fetal hearts by DT-MRI. We have developed the method of finding the vortex center based on the distribution of the primary eigenvector in the heart apex.

Keywords:fetal heart, vortex, myocardial fiber orientation, DT-MRI