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Best Research Papers in the Field of Sensors, Signals, and Imaging Informatics 2021

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Summary

Objective: In this synopsis, we identify and highlight research papers representing noteworthy developments in signals, sensors, and imaging informatics in 2021.

Method: A broad literature search was conducted on PubMed and Scopus databases. We combined Medical Subject Heading (MeSH) terms and keywords to construct particular queries for sensors, signals, and imaging informatics. Except for the sensor section, we only consider papers that have been published in journals providing at least three articles in the query response. Using a three-point Likert scale (1 = not include, 2 = maybe include, and 3 = include), we reviewed the titles and abstracts of all database returns. Only those papers which reached two times three points were further considered for full paper review using the same Likert scale. Again, we only considered works with two times three points and provided these for external reviews. Based on the external reviews, we selected three best papers, as it happens that the three highest ranked papers represent works from all three parts of this section: sensors, signals, and imaging informatics.

Results: The search for papers was executed in January 2022. After removing duplicates and conference proceedings, the query returned a set of 88, 376, and 871 papers for sensors, signals, and imaging informatics, respectively. For signals and images,

we filtered out journals that had less than three papers in the query results, reducing the number of papers to 215 and 512, respectively. From this total of 815 papers, the section co-editors identified 35 candidate papers with two times three Likert points, from which nine candidate best papers were nominated after full paper assessment. At least three external reviewers then rated the remaining papers and the three best-ranked papers were selected using the composite rating of all external reviewers. By accident, these three papers represent each of the three fields of sensor, signal, and imaging informatics. They were approved by consensus of the International Medical Informatics Association (IMIA) Yearbook editorial board. Deep and machine learning techniques are still a dominant topic as well as concepts beyond the state-of-the-art.

Conclusions. Sensors, signals, and imaging informatics is a dynamic field of intense research. Current research focuses on creating and processing heterogeneous sensor data towards meaningful decision support in clinical settings.

Keywords

Sensors; signals; imaging informatics; medical informatics

is to identify notable research in the entire field. Again, the majority of research papers have applied deep learning approaches to well-documented SSII problems and identifying real novelty is difficult. However, SSII is more than 'just' deep learning [8]. As such, our objective was to systematically catch the spectrum of work—including all machine learning techniques—that best represent the SSII developments and achievements in 2021.

2   Paper Selection Process

The process of searching the literature for candidate best papers of the SSII section remained a challenging task, given the broad nature of the SSII category. This year, we harmonized the search terms and acronyms and completed the queries that were applied over the last years [1, 4, 5]. Still, we focused on research articles in the English language and excluded review papers. Then, we ran the queries separately for sensors, signals, and images in PubMed and Scopus (see Appendix 2).

In mid-January 2022, we executed the final query. After removing duplicates and conference proceedings, the query returned a set of 88, 376, and 871 papers for sensors, signals, and imaging informatics, respectively. As we did last year [1], we set the threshold of at least three papers in a relevant journal and excluded articles from irrelevant journals. Due to the retrieval numbers, we applied this rule to signals and images only, resulting in 215 and 512 papers, respectively.

1   Introduction

Hsu *et al.*, have defined sensors, signals, and imaging informatics (SSII) as three independent parts, although signal and imaging informatics are more related [1]. A biomedical signal and a medical image can be considered as a one-dimensional and a two- or more-dimensional stream, respectively, and the methods applied are

similar. Contrarily, the sensor's part is more device-oriented [2]. SSII spans a huge field of research, and thousands of papers are published every year [3-5]. Searching for "sensor informatics", "signal informatics", or "imaging informatics" in the title of papers published in 2021, we identified two new reviews, both focusing on the role of medical images in fighting the COVID-19 pandemic [6, 7]. In contrast, our annual task

Then, we reviewed 815 titles and abstracts and independently ranked them on a three-point Likert scale (1=not include, 2=maybe include, and 3=include). For 35 papers, both section co-editors agreed on 3 points. We then assessed the full paper, again using the same three-point Likert scale. Finally, we found nine papers where the section co-editors agreed on three points: 4, 3, and 2 from sensor, signal, and imaging informatics, respectively. In agreement with the IMIA Yearbook Editors in Chief, we uploaded these nine papers for external review. After external review, the first, second, and third top-ranked papers were from signal, sensor, and imaging informatics, respectively. As the three best-ranked papers represent all of our sections, we suggested the IMIA Yearbook Editors in Chief to include all three, which has been approved at the editorial board meeting.

We want to mention that this year, it happens that a section co-editor also was co-author of one of the nine finalist papers. This issue was discussed with the IMIA Yearbook Editors in Chief and it was recommended that the section co-editor shall be excluded from the final evaluation of this particular work, but evaluate the remaining eight papers, which we did accordingly.

3 Emerging Trends and New Directions

The literature reviewed and preselected this year revealed a number of interesting methodological approaches in the field of SSII. Here, we highlight emerging trends, particularly focusing on new developments in combining advanced sensor technologies and signal processing approaches, as well as the trend toward artificial intelligence (AI)-based methods in medical image processing, which has become prevalent in recent years.

3.1 Advanced Sensing and Signal Processing Approaches

One trend that continues to gain traction is the use of known cardiac, neural, or muscular sensing technologies (EEG, ECG, EMG,

Table 1 Best paper selection for the 2022 IMIA Yearbook of Medical Informatics for the 'Sensors, signals, and imaging informatics' section. Articles are listed in alphabetical order of the first author's surname.

Section
Sensors, Signals, and Imaging Informatics
▪ Ganapathy N, Baumgärtel D, Deserno TM. Automatic detection of atrial fibrillation in ECG using co-occurrence patterns of dynamic symbol assignment and machine learning. Sensors (Basel) 2021 May 19;21(10):3542.
▪ He Y, Carass A, Zuo L, Dewey BE, Prince JL. Autoencoder based self-supervised test-time adaptation for medical image analysis. Med Image Anal 2021 Aug;72:102136.
▪ Jeong H, Kwak SS, Sohn S, Lee JY, Lee YJ, O'Brien MK, Park Y, Avila R, Kim JT, Yoo JY, Irie M, Jang H, Ouyang W, Shawen N, Kang YJ, Kim SS, Tzavelis A, Lee K, Andersen RA, Huang Y, Jayaraman A, Davis MM, Shanley T, Wakschlag LS, Krogh-Jespersen S, Xu S, Ryan SW, Lieber RL, Rogers JA. Miniaturized wireless, skin-integrated sensor networks for quantifying full-body movement behaviors and vital signs in infants. Proc Natl Acad Sci U S A 2021 Oct 26;118(43):e2104925118.

blood pressure, body temperature, and others) in combination with novel machine and deep learning (DL) methods to extract additional physiological information from standard, clinically approved applications and novel sensing environments and settings.

Beyond the best papers selected this year, in which Jeong *et al.,* presented a miniaturized wireless, skin-integrated sensor network for quantifying body movements in infants [9], and Ganapathy *et al.*, who introduced an approach on automatic detection of atrial fibrillation in ECG using machine learning [10] (Appendix 1) other innovative developments were published.

For example, Zang *et al.*, presented EEGdenoiseNet, a benchmark EEG dataset in neuroscience that is suited for accelerating the training and testing DL-based denoising models, as well as for performance comparisons across such models [11]. Yu *et al.*, proposed a transfer learning strategy for instant gesture recognition through surface electromyography (sEMG)-based human-computer interaction, which is based on a convolutional neural network (CNN) and improves the generalization performance of the target networks [12]. A cuff-free method to estimate the morphology of the average arterial blood pressure and pulse rate through a DL model based on a seq2seq architecture with attention mechanism is presented in the work of Aguirre *et al.*, which is potentially useful for wireless devices [13]. In the context of the coronavirus disease (COVID-19), Maille *et al.*, published a study using a smartwatch-based ECG in

combination with AI-based signal analysis to assess the cardiac-rhythm safety of drug therapy suitable for QTc interval monitoring under these challenging conditions [14].

Interestingly, another trend has been observed that goes beyond the measurement of physiological signals to include more bioanalytical signals. Lee *et al.*, proposed a biomedical sensor system for continuous monitoring of glucose concentration using a batteryless, miniaturized implantable fluorescent hydrogel-based sensor with a wireless data interface [15]. A silicon micropillar array-based wearable sweat glucose sensor was developed by Dervisevic *et al.*, which offers a user-friendly, cost-effective, and reliable sweat analysis platform, having a great potential in health monitoring and disease prognostics [16].

3.2 Deep Learning-based Approaches in Medical Image Processing

In the field of imaging informatics, this year the work of He *et al.*, was selected as one of the best papers, presenting an autoencoder-based self-supervised test-time adaptation for medical image analysis using a DL-based model [17] (Appendix 1).

The large majority of papers presented machine or DL-based approaches, a rapidly growing trend in this field. For medical image segmentation, a novel CNN quantization framework was developed by Zhang *et al.*, that can squeeze a deep model to

extremely low bit width, while maintaining its high performance and thus outperforms state-of-the-art quantization approaches significantly [18].

DL methods are also used as powerful anaylsis tools for microscopy. Von Camier *et al.*, provides an entry-level platform that simplifies DL access by leveraging free, cloud-based computational resources [19]. This platform allows users with no coding expertise to train and apply DL networks for image segmentation and object detection, de-noising, super-resolution, and image-to-im-age translation.

Dinsdale *et al.*, introduced a DL-based unlearning of dataset bias for magnetic res-onance imaging (MRI) harmonisation and confound removal [20]. The framework is used for regression, classification, and seg-mentation tasks with two different network architectures, and it is flexible and applicable to a wide range of neuroimaging studies.

An interesting work was also presented by Tang *et al.*, introducing a frequency rep-resentation into CNNs for medical image segmentation using a twin-kernel Fourier transform [21]. This approach was evaluated on skin lesion, retinal blood vessel, lung and brain tumor segmentation datasets, achieving outstanding results.

4 Discussion and Conclusion

We want to stress that although we worked a lot towards a "perfect" wording of the three queries, novel terms, techniques, and tech-nologies appear and the queries will require a continuous refinement of query wording. In other words, the "perfect" query will never be obtained, which makes it difficult to compare retrieval numbers between the years. Another limitation is the different spelling of journal names, which we will take into consideration by next year. Indeed, if the same journal is spelled differently, the at-least-three count fails. Unfortunately, we observed this "bug" quite late in the evaluation process and were not been able to correct anymore. Furthermore, the at-least-three rule should be normalized to the total number of papers that have been published by each journal. For instance,

three out of 8,599 papers in Sensors (Basel)[1] should count differently as three out of 31 in Methods of Information in Medicine[2].

SSII continues to be a central topic in the field of medical informatics with a growing number of publications. A major emerging trend in signal and image processing is the use of machine learning and increasingly DL-based methods to extract new or addi-tional clinical information from continuously streamed data, but also to further improve the quality of selected information through improved data transformation concepts and extensive validation with appropriate large data sources.

At the level of sensor technologies also an increasing number of papers were found on sensors measuring bioanalytes such as glucose levels embedded in promising health care applications, in addition to measuring and interpreting traditional physiological signals. Sensor networks and wireless data exchange complement this development.

In the face of the COVID-19 pandemic, many innovations in SSII continued to address the pandemic situation to further improve diagnostic approaches and patient management. In future, SSII will benefit from the new innovations in data and infor-mation science by taking advantage of new technological developments in biomedical sensing and imaging.

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Appendix 1: Content Summaries of Selected Best Papers for the 2022 IMIA Yearbook, Section Sensors, Signals, and Imaging Informatics

Jeong H, Kwak SS, Sohn S, Lee JY, Lee YJ, O'Brien MK, Park Y, Avila R, Kim JT, Yoo JY, Irie M, Jang H, Ouyang W, Shawen N, Kang YJ, Kim SS, Tzavelis A, Lee K, Andersen RA, Huang Y, Jayaraman A, Davis MM, Shanley T, Wakschlag LS, Krogh-Jespersen S, Xu S, Ryan SW, Lieber RL, Rogers JA

Miniaturized wireless, skin-integrated sensor networks for quantifying full-body movement behaviors and vital signs in infants

Proc Natl Acad Sci U S A 2021 Oct 26;118(43):e2104925118

The detection of atypical movement behaviors in infants is critical for timely therapeutic interventions based on early childhood neuroplasticity. In this work, the authors impressively present a simple, cost-effective alternative in the form of a customized technology to quantitatively record whole-body kinematics of infants under free-living conditions while recording important vital signs. Since conventional assessments rely on subjective expert evaluations or specialized medical facilities, the technology used is based on wireless networks of miniaturized, skin-integrated sensors placed at strategic locations across the body, operating in a wide-bandwidth and time-synchronized fashion. Recorded data of individual movement behavior serve as the basis for reconstructing three-dimensional motion in the form of avatars, without the need for video recording and the associated privacy concerns. Clinical application in infants at low and increased risk for atypical neuromotor development demonstrates the applicability of this system with quantitative assessment of patterns of gross motor skills, along with cardiopulmonary information such as body temperature, heart and respiratory rate from long-term and follow-up measurements over a 3-month period after birth. The work stands out for its excellent applicability, as the outputs from these sensors can be linked to established educational resources on motor development via mobile applications to support early detection of abnormalities in home and clinical settings. The technology presented thus enables rapid, routine evaluations of infants at any age and has potential for use in nearly any setting across developed and developing countries.

Ganapathy N, Baumgärtel D, Deserno TM

Automatic detection of atrial fibrillation in ECG using co-occurrence patterns of dynamic symbol assignment and machine learning

Sensors (Basel) 2021 May 19;21(10):3542

Early detection of atrial fibrillation from electrocardiography (ECG) plays a vital role in the timely prevention and diagnosis of cardiovascular diseases. Symbolic classifiers aim at capturing the concepts behind the measured data. As novelty, this paper relates symbols to the definition range to the signal, but not to the value range, as previous approaches exclusively did. In particular, the authors transform interbeat intervals into an adaptive symbolic representation and compute co-occurrence matrices on the symbols. They vary symbol-length, word-size, and applied to five machine learning algorithms for classification. The approach is tested on public available data (AF Prediction Challenge Database (AFPDB) and AF Termination Challenge Database (AFTDB)) as well as private data from capacitive and textile ECG electrodes, the latter providing noisy recordings. The approach outperforms the state of the art in terms of accuracy and is efficient for real-time and mobile applications, and robust on noisy data.

He Y, Carass A, Zuo L, Dewey BE, Prince JL

Autoencoder based self-supervised test-time adaptation for medical image analysis

Med Image Anal 2021 Aug;72:102136

The use of deep neural networks for medical image analysis tasks such as segmentation and synthesis has become very important in recent years. A major challenge remains the problem of performance drop, even when a network is trained on a large dataset. In this work, the authors propose a model that adapts during inference based on a single subject to overcome the lack of availability of training data and the cost of training a new model. The model consists of three neural networks: (i) a task model which can be any state-of-the-art model that performs image analysis, e.g. segmentation, (ii) a set of multi-level fully convolutional autoencoders to encode the image level, feature levels, and output prediction level distributions of the source domain, and (iii) a set of adaptors that test data to the source domain in both, the pixel-level and feature-level to improve the final prediction. The task model and autoencoders are trained with a labeled source dataset. This is computationally expensive, but the model only needs to be trained once. In the deployment stage, the adaptors are trained to transform the test image and its features to minimize the domain shift as measured by the autoencoders' reconstruction loss, which is computationally efficient. The method achieves significant performance improvement and was validated on retinal optical cohenrece tomography image segmentation and MRI T1-weighted to T2-weighted image synthesis. The work is noteworthy for its high potential for developing a clinically robust and easily deployable deep network.

Appendix 2: Queries used for Candidate Paper Retrieval

The queries used to retrieve literature from PubMed and Scopus differ slightly, as the databases do not use the same data fields and query syntax. Furthermore, we have harmonized the queries used by Hsu *et al.*, in [1].

2.1 Sensors

2.1.1 PubMed Query

(("2021/01/01"[DP] : "2021/12/31"[DP]) AND Journal Article [pt] AND English[lang] AND hasabstract[text] NOT Bibliography[pt] NOT Comment[pt] NOT Editorial[pt] NOT Letter[pt] NOT News[pt] NOT Review[pt] NOT Case Reports[pt] NOT Published Erratum[pt] NOT Historical Article[pt] NOT legislation[pt] NOT "clinical trial"[pt] NOT "evaluation studies"[pt] NOT "technical report"[pt] NOT "Scientific Integrity Review"[pt] NOT "Systematic Review"[pt] NOT "Retracted Publication"[pt]) AND (("sensor"[TI] OR "sensors"[TI] OR "sensing"[TI]) AND ("vital sign"[TI] OR "vital signs"[TI] OR "biological signal"[TI] OR "biological signals"[TI] OR "biological parameter"[TI] OR "biological parameters"[TI] OR "physiological parameter"[TI] OR "physiological parameters"[TI] OR "physiological signal"[TI] OR "physiological signals"[TI] OR "blood pressure"[TI] OR "temperature"[TI] OR "heart rate"[TI] OR "heartbeat"[TI] OR "heartbeats"[TI] OR "pulse rate"[TI] OR "respiration rate"[TI] OR "respiratory rate"[TI] OR "breathing rate"[TI] OR "ECG"[TI] OR "electrocardiography"[TI] OR "electrocardiogram"[TI] OR "menstrual cycle"[TI] OR "oxygen"[TI] OR "oximetry"[TI] OR "glucose"[TI] OR "end-tidal"[TI] OR "emg"[TI] OR "electromyography"[TI] OR "electromyogram"[TI] OR "ppg"[TI] OR "photoplethysmography"[TI] OR "photoplethysmogram"[TI] OR "pcg"[TI] OR "phonocardiography"[TI] OR "phonocardiogram"[TI] OR "bcg"[TI] OR "ballistocardiography"[TI] OR "ballistocardiogram"[TI] OR "scg"[TI] OR "seismocardiography"[TI] OR "seismocardiogram"[TI] OR "eog"[TI] OR "electrooculography"[TI] OR "electrooculogram"[TI] OR "eda"[TI] OR "electrodermal activity"[TI] OR "GSR"[TI] OR "Galvanic skin response" [TI] OR "eeg"[TI] OR "electroencephalogram"[TI] OR "bci"[TI] OR "brain computer interface"[TI]) NOT ("review"[TI] OR "survey"[TI] OR "conference"[ta])) AND ("medic*"[TIAB] OR "biomed*"[TIAB] OR "biologic*[TIAB]")

2.1.2 Scopus Query

TITLE(("sensor" OR "sensors" OR "sensing") AND ("vital sign" OR "vital signs" OR "biological signal" OR "biological signals" OR "biological parameter" OR "biological parameters" OR "physiological parameter" OR "physiological parameters" OR "physiological signal" OR "physiological signals" OR "blood pressure" OR "temperature" OR "heart rate" OR "heartbeat" OR "heartbeats" OR "pulse rate" OR "respiration rate" OR "respiratory rate" OR "breathing rate" OR "ECG" OR "electrocardiography" OR "electrocardiogram" OR "menstrual cycle" OR "oxygen" OR "oximetry" OR "glucose" OR "end-tidal" OR "emg" OR "electromyography" OR "electromyogram" OR "ppg" OR "photoplethysmography" OR "photoplethysmogram" OR "pcg" OR "phonocardiography" OR "phonocardiogram" OR "bcg" OR "ballistocardiography" OR "ballistocardiogram" OR "scg" OR "seismocardiography" OR "seismocardiogram" OR "eog" OR "electrooculography" OR "electrooculogram" OR "eda" OR "electrodermal activity" OR "GSR" OR "Galvanic skin response" OR "eeg" OR "electroencephalogram" OR "bci" OR "brain computer interface") AND NOT ("review" OR "survey")) AND TITLE-ABS ("application") AND PUBDATETXT("January 2021" OR "February 2021" OR "March 2021" OR "April 2021" OR "May 2021" OR "June 2021" OR "July 2021" OR "August 2021" OR "September 2021" OR "October 2021" OR "November 2021" OR "December 2021") AND LANGUAGE(english) AND SUBJAREA(MEDI) AND SRCTYPE(j) AND DOCTYPE(ar) AND NOT DOCTYPE(re)

2.2 Signals

2.2.1 PubMed Query

(("2021/01/01"[DP] : "2021/12/31"[DP]) AND Journal Article [pt] AND English[lang] AND hasabstract[text] NOT Bibliography[pt] NOT Comment[pt] NOT Editorial[pt] NOT Letter[pt] NOT News[pt] NOT Review[pt] NOT Case Reports[pt] NOT Published Erratum[pt] NOT Historical Article[pt] NOT legislation[pt] NOT "clinical trial"[pt] NOT "evaluation studies"[pt] NOT "technical report"[pt] NOT "Scientific Integrity Review"[pt] NOT "Systematic Review"[pt] NOT "Retracted Publication"[pt]) AND (("biosignal"[TI] OR "biomedical signal"[TI] OR "physiological signal"[TI] OR "ecg"[TI] OR "electrocardiography"[TI] OR "electrocardiogram"[TI] OR "emg"[TI] OR "electromyography"[TI] OR "electromyogram"[TI] OR "ppg"[TI] OR "photoplethysmography"[TI] OR "photoplethysmogram"[TI] OR "pcg"[TI] OR "phonocardiography"[TI] OR "phonocardiogram"[TI] OR "bcg"[TI] OR "ballistocardiography"[TI] OR "ballistocardiogram"[TI] OR "scg"[TI] OR "seismocardiography"[TI] OR "seismocardiogram"[TI] OR "eog"[TI] OR "electrooculography"[TI] OR "electrooculogram"[TI] OR "eda"[TI] OR "electrodermal activity"[TI] OR "Respiration"[TI] OR "Blood Pressure"[TI] OR "eeg"[TI] OR "electroencephalogram"[TI] OR "bci"[TI] OR "brain computer interface"[TI]) AND ("processing"[TI] OR "analytics"[TI] OR "analysis"[TI] OR "analyse"[TI] OR "analyze"[TI] OR "analysing"[TI] OR "analyzing"[TI] OR "enhancement"[TI] OR "enhancements"[TI] OR "segmentation"[TI] OR "feature extraction"[TI] OR "feature selection"[TI] OR "classification"[TI] OR "clustering"[TI] OR "measurement"[TI] OR "quantification"[TI] OR "registration"[TI] OR "recognition"[TI] OR "reconstruction"[TI] OR "interpretation"[TI] OR "retrieval"[TI] "augmentation"[TI] OR

"data mining"[TI] OR "computer-assisted"[TI] OR "computer-aided"[TI] OR "artificial intelligence"[TI] OR "machine learning"[TI] OR "deep learning"[TI] OR "neural network"[TI] OR "computer vision"[TI] OR "autoencoder"[TI] OR "auto-encoder"[TI] OR "Botzmann"[-TI] OR "U-net"[TI] OR "support vector machine"[TI] OR "SVM"[TI] OR "random forest"[TI]) NOT ("review"[TI] OR "survey"[TI] OR "conference"[ta]))

2.2.2 Scopus Query

TITLE((("signal" OR "biosignal" OR "biomedical signal" OR "physiological signal" OR "ecg" OR "electrocardiography" OR "electrocardiogram" OR "emg" OR "electromyography" OR "electromyogram" OR "ppg" OR "photoplethysmography" OR "photoplethysmogram" OR "pcg" OR "phonocardiography" OR "phonocardiogram" OR "bcg" OR "ballistocardiography" OR "ballistocardiogram" OR "scg" OR "seismocardiography" OR "seismocardiogram" OR "eog" OR "electrooculography" OR "electrooculogram" OR "eda" OR "electrodermal activity" OR "Respiration" OR "Blood Pressure" OR "eeg" OR "electroencephalogram" OR "bci" OR "brain computer interface") AND ("processing" OR "analytics" OR "analysis" OR "analyse" OR "analyze" OR "analysing" OR "analyzing" OR "enhancement" OR "enhancements" OR "segmentation" OR "feature extraction" OR "feature selection" OR "classification" OR "clustering" OR "measurement" OR "quantification" OR "registration" OR "recognition" OR "reconstruction" OR "interpretation" OR "retrieval" "augmentation" OR "data mining" OR "computer-assisted" OR "computer-aided" OR "artificial intelligence" OR "machine learning" OR "deep learning" OR "neural network" OR "computer vision" OR "autoencoder" OR "auto-encoder" OR "Botzmann" OR "U-net" OR "support vector machine" OR "SVM" OR "random forest") AND NOT ("review" OR "survey")) AND PUBDATETXT("January 2021" OR "February 2021" OR "March 2021" OR "April 2021" OR "May 2021" OR "June 2021" OR "July 2021" OR "August 2021" OR "September 2021" OR "October 2021" OR "November 2021" OR "December 2021") AND LANGUAGE(english) AND SUBJAREA(MEDI) AND SRCTYPE(j) AND DOCTYPE(ar) AND NOT DOCTYPE(re)

2.3 Imaging Informatics

2.3.1 PubMed Query

(("2021/01/01"[DP] : "2021/12/31"[DP]) AND Journal Article [pt] AND English[lang] AND hasabstract[text] NOT Bibliography[pt] NOT Comment[pt] NOT Editorial[pt] NOT Letter[pt] NOT News[pt] NOT Review[pt] NOT Case Reports[pt] NOT Published Erratum[pt] NOT Historical Article[pt] NOT legislation[pt] NOT "clinical trial"[pt] NOT "evaluation studies"[pt] NOT "technical report"[pt] NOT "Scientific Integrity Review"[pt] NOT "Systematic Review"[pt] NOT "Retracted Publication"[pt]) AND (("image"[TI] OR "imaging"[TI] OR "video"[TI] OR "X-ray"[TI] OR "X ray"[TI] OR "radiography"[TI] OR "orthopantomography"[TI] OR "fluoroscopy"[TI] OR "angiography"[TI] OR "tomography"[TI] OR "CT"[TI] OR "magnetic resonance"[TI] OR "MRI"[TI] OR "echocardiography"[TI] OR "sonography"[TI] OR "ultrasound"[TI] OR "endoscopy"[TI] OR "arthroscopy"[TI] OR "bronchoscopy"[TI] OR "colonoscopy"[TI] OR "cystoscopy"[TI] OR "laparoscopy"[TI] OR "nephroscopy"[TI] OR "laryngoscopy" [TI] OR "funduscopy"[TI] OR "thermography"[TI] OR "photography"[TI] OR "arthroscopy"[TI] OR "microscopy"[TI]) AND ("processing"[TI] OR "analytics"[TI] OR "analysis"[TI] OR "analyse"[TI] OR "analyze"[TI] OR "analysing"[TI] OR "analyzing"[TI] OR "enhancement"[TI] OR "enhancements"[TI] OR "segmentation"[TI] OR "feature extraction"[TI] OR "feature selection"[-TI] OR "classification"[TI] OR "clustering"[TI] OR "measurement"[TI] OR "quantification"[TI] OR "registration"[TI] OR "recognition"[TI] OR "reconstruction"[TI] OR "interpretation"[TI] OR "retrieval"[TI] "augmentation"[TI] OR "data mining"[TI] OR "computer-assisted"[TI] OR "computer-aided"[TI] OR "artificial intelligence"[TI] OR "machine learning"[TI] OR "deep learning"[TI] OR "neural network"[TI] OR "computer vision"[TI] OR "autoencoder"[TI] OR "auto-encoder"[TI] OR "Botzmann"[TI] OR "U-net"[TI] OR "support vector machine"[TI] OR "SVM"[TI] OR "random forest"[TI]) NOT ("review"[TI] OR "survey"[TI] OR "conference"[ta])) AND ("medical informatics"[MH])

2.3.2 Scopus Query

TITLE((("image" OR "imaging" OR "video" OR "X-ray" OR "X ray" OR "radiography" OR "orthopantomography" OR "fluoroscopy" OR "angiography" OR "tomography" OR "CT" OR "magnetic resonance" OR "MRI" OR "echocardiography" OR "sonography" OR "ultrasound" OR "endoscopy" OR "arthroscopy" OR "bronchoscopy" OR "colonoscopy" OR "cystoscopy" OR "laparoscopy" OR "nephroscopy" OR "laryngoscopy" OR "funduscopy" OR "thermography" OR "photography" OR "arthroscopy" OR "microscopy") AND ("processing" OR "analytics" OR "analysis" OR "analyse" OR "analyze" OR "analysing" OR "analyzing" OR "enhancement" OR "enhancements" OR "segmentation" OR "feature extraction" OR "feature selection" OR "classification" OR "clustering" OR "measurement" OR "quantification" OR "registration" OR "recognition" OR "reconstruction" OR "interpretation" OR "retrieval" "augmentation" OR "data mining" OR "computer-assisted" OR "computer-aided" OR "artificial intelligence" OR "machine learning" OR "deep learning" OR "neural network" OR "computer vision" OR "autoencoder" OR "auto-encoder" OR "Botzmann" OR "U-net" OR "support vector machine" OR "SVM" OR "random forest") AND NOT ("review" OR "survey")) AND PUBDATETXT("January 2021" OR "February 2021" OR "March 2021" OR "April 2021" OR "May 2021" OR "June 2021" OR "July 2021" OR "August 2021" OR "September 2021" OR "October 2021" OR "November 2021" OR "December 2021") AND LANGUAGE(english) AND SUBJAREA(MEDI) AND SRCTYPE(j) AND DOCTYPE(ar) AND NOT DOCTYPE(re)