

Founding Editors

Gerhard Goos

Karlsruhe Institute of Technology, Karlsruhe, Germany

Juris Hartmanis

Cornell University, Ithaca, NY, USA


Editorial Board Members

Elisa Bertino

Purdue University, West Lafayette, IN, USA

Wen Gao

Peking University, Beijing, China

Bernhard Steffen 

TU Dortmund University, Dortmund, Germany

Gerhard Woeginger 

RWTH Aachen, Aachen, Germany

Moti Yung 

Columbia University, New York, NY, USA

More information about this subseries at <https://link.springer.com/bookseries/7412>

Moi Hoon Yap · Bill Cassidy ·
Connah Kendrick (Eds.)

Diabetic Foot Ulcers Grand Challenge

Second Challenge, DFUC 2021
Held in Conjunction with MICCAI 2021
Strasbourg, France, September 27, 2021
Proceedings

Editors

Moi Hoon Yap 
Manchester Metropolitan University
Manchester, UK

Bill Cassidy 
Manchester Metropolitan University
Manchester, UK

Connah Kendrick 
Manchester Metropolitan University
Manchester, UK

ISSN 0302-9743

ISSN 1611-3349 (electronic)

Lecture Notes in Computer Science

ISBN 978-3-030-94906-8

ISBN 978-3-030-94907-5 (eBook)

<https://doi.org/10.1007/978-3-030-94907-5>

LNCS Sublibrary: SL6 – Image Processing, Computer Vision, Pattern Recognition, and Graphics

© Springer Nature Switzerland AG 2022

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

This is the first proceedings of Diabetic Foot Ulcer (DFU) research focusing on the DFU Challenge 2021 (DFUC 2021), organized in conjunction with the 24th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI 2021). Due to the COVID-19 pandemic, the challenge event was conducted online on September 27, 2021. We received 500 submissions for the validation stage and 28 submissions for the testing stage.

The overall goal of the DFU challenge is to solicit original works in DFU and to promote interactions between researchers and interdisciplinary (national and international) collaborators. It aims to motivate the health care domain to share datasets, participate in ground truth annotation, and enable data-innovation in computer algorithm development. In the longer term, it will lead to improved patient care and reduce the strain on overburdened healthcare systems. With joint efforts from the lead scientists of the UK, US, India, and New Zealand, these inaugural challenges were well-received, with the first DFU challenge successfully conducted in 2020 for the task of DFU detection. The task of DFUC 2021 related to multi-class classification, for the purpose of supporting research towards more advanced methods of DFU pathology recognition.

This proceedings provides an overview of the development of DFU datasets, gathers methodological papers of classification methods evaluated at the DFUC 2021 along with a DFUC 2021 summary paper from the organizers, and considers post challenge papers. Apart from the Overview and Summary paper, all papers were reviewed by three reviewers and assigned to a meta-reviewer. For DFUC 2021 papers a single-blind review process was used, accepting only the top five entries due to the proceedings call for papers deadline. For the post challenge papers, a double-blind review process was completed with a 25% acceptance rate. In total we received four post challenge papers with only one accepted. The organizers were not listed as authors for the challenge and post challenge papers.

As a concluding note, the organizers of the challenge continue to support the research community by providing a live leaderboard to test the performance of their algorithms. To date, there are 350 submissions on the live leaderboard, with approximately 10 submissions per day. Researchers who are interested in the challenge can request the datasets and evaluate the task on our grand challenge websites (DFU detection task and DFU classification task). The organizers will conduct DFUC 2022 in conjunction with MICCAI 2022, with the task focusing on DFU segmentation.

December 2021

Moi Hoon Yap
Bill Cassidy
Connah Kendrick

Organization

General Chairs

Moi Hoon Yap	Manchester Metropolitan University, UK
Bill Cassidy	Manchester Metropolitan University, UK
Neil Reeves	Manchester Metropolitan University, UK

Organizing Committee

Moi Hoon Yap	Manchester Metropolitan University, UK
Neil Reeves	Manchester Metropolitan University, UK
Andrew Boulton	University of Manchester and Manchester Infirmary, UK
Satyan Rajbhandari	Lancashire Teaching Hospitals, UK
David Armstrong	University of Southern California, USA
Arun G. Maiya	Manipal College of Health Professions, India
Bijan Najafi	Baylor College of Medicine, USA
Bill Cassidy	Manchester Metropolitan University, UK
Justina Wu	Waikato District Health Board, New Zealand

Clinical Chairs

Joseph M. Pappachan	Lancashire Teaching Hospitals, UK
Claire O'Shea	Waikato District Health Board, New Zealand

Technical Chairs

Connah Kendrick	Manchester Metropolitan University, UK
David Gillespie	Manchester Metropolitan University, UK

Program Committee Chair

Connah Kendrick	Manchester Metropolitan University, UK
-----------------	--

Program Committee

Christoph Friedrich (Area Chair)	University of Applied Sciences and Arts Dortmund, Germany
Azadeh Alavi (Area Chair)	Royal Melbourne Institute of Technology, Australia
Salman Ahmed	National University of Computer and Emerging Sciences, Pakistan
Nora Al-Garaawi	University of Kufa, Iraq
David Asher	Baker Heart and Diabetes Institute, Australia
Raphael Brüngel	University of Applied Sciences and Arts Dortmund, Germany
Bill Cassidy	Manchester Metropolitan University, UK
Adrian Galdran	Bournemouth University, UK
Manu Goyal	UT Southwestern Medical Center, USA
Orhun Güley	Technical University of Munich, Germany
Christian Igel	University of Copenhagen, Denmark
Abdul Qayyum	National Engineering School of Brest, France

Sponsors



Contents

Development of Diabetic Foot Ulcer Datasets: An Overview	1
<i>Moi Hoon Yap, Connah Kendrick, Neil D. Reeves, Manu Goyal, Joseph M. Pappachan, and Bill Cassidy</i>	
DFUC 2021 Challenge Papers	
Convolutional Nets Versus Vision Transformers for Diabetic Foot Ulcer Classification	21
<i>Adrian Galdran, Gustavo Carneiro, and Miguel A. González Ballester</i>	
Boosting EfficientNets Ensemble Performance via Pseudo-Labels and Synthetic Images by pix2pixHD for Infection and Ischaemia Classification in Diabetic Foot Ulcers	30
<i>Louise Bloch, Raphael Brüngel, and Christoph M. Friedrich</i>	
Bias Adjustable Activation Network for Imbalanced Data—Diabetic Foot Ulcer Challenge 2021	50
<i>Salman Ahmed and Hammad Naveed</i>	
Efficient Multi-model Vision Transformer Based on Feature Fusion for Classification of DFUC2021 Challenge	62
<i>Abdul Qayyum, Abdesslam Benzinou, Moona Mazher, and Fabrice Meriaudeau</i>	
Classification of Infection and Ischemia in Diabetic Foot Ulcers Using VGG Architectures	76
<i>Orhun Güley, Sarthak Pati, and Spyridon Bakas</i>	
Diabetic Foot Ulcer Grand Challenge 2021: Evaluation and Summary	90
<i>Bill Cassidy, Connah Kendrick, Neil D. Reeves, Joseph M. Pappachan, Claire O'Shea, David G. Armstrong, and Moi Hoon Yap</i>	
Post Challenge Paper	
Deep Subspace Analysing for Semi-supervised Multi-label Classification of Diabetic Foot Ulcer	109
<i>Azadeh Alavi and Hossein Akhoundi</i>	
Author Index	121