

Andrea Vedaldi
Horst Bischof
Thomas Brox
Jan-Michael Frahm (Eds.)

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Computer Vision – ECCV 2020

16th European Conference
Glasgow, UK, August 23–28, 2020
Proceedings, Part I

1
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Oxford, UK

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Jan-Michael Frahm
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Foreword

Hosting the European Conference on Computer Vision (ECCV 2020) was certainly an exciting journey. From the 2016 plan to hold it at the Edinburgh International Conference Centre (hosting 1,800 delegates) to the 2018 plan to hold it at Glasgow's Scottish Exhibition Centre (up to 6,000 delegates), we finally ended with moving online because of the COVID-19 outbreak. While possibly having fewer delegates than expected because of the online format, ECCV 2020 still had over 3,100 registered participants.

Although online, the conference delivered most of the activities expected at a face-to-face conference: peer-reviewed papers, industrial exhibitors, demonstrations, and messaging between delegates. In addition to the main technical sessions, the conference included a strong program of satellite events with 16 tutorials and 44 workshops.

Furthermore, the online conference format enabled new conference features. Every paper had an associated teaser video and a longer full presentation video. Along with the papers and slides from the videos, all these materials were available the week before the conference. This allowed delegates to become familiar with the paper content and be ready for the live interaction with the authors during the conference week. The live event consisted of brief presentations by the oral and spotlight authors and industrial sponsors. Question and answer sessions for all papers were timed to occur twice so delegates from around the world had convenient access to the authors.

As with ECCV 2018, authors' draft versions of the papers appeared online with open access, now on both the Computer Vision Foundation (CVF) and the European Computer Vision Association (ECVA) websites. An archival publication arrangement was put in place with the cooperation of Springer. SpringerLink hosts the final version of the papers with further improvements, such as activating reference links and supplementary materials. These two approaches benefit all potential readers: a version available freely for all researchers, and an authoritative and citable version with additional benefits for SpringerLink subscribers. We thank Alfred Hofmann and Aliaksandr Birukou from Springer for helping to negotiate this agreement, which we expect will continue for future versions of ECCV.

August 2020

Vittorio Ferrari
Bob Fisher
Cordelia Schmid
Emanuele Trucco

Preface

Welcome to the proceedings of the European Conference on Computer Vision (ECCV 2020). This is a unique edition of ECCV in many ways. Due to the COVID-19 pandemic, this is the first time the conference was held online, in a virtual format. This was also the first time the conference relied exclusively on the Open Review platform to manage the review process. Despite these challenges ECCV is thriving. The conference received 5,150 valid paper submissions, of which 1,360 were accepted for publication (27%) and, of those, 160 were presented as spotlights (3%) and 104 as orals (2%). This amounts to more than twice the number of submissions to ECCV 2018 (2,439). Furthermore, CVPR, the largest conference on computer vision, received 5,850 submissions this year, meaning that ECCV is now 87% the size of CVPR in terms of submissions. By comparison, in 2018 the size of ECCV was only 73% of CVPR.

The review model was similar to previous editions of ECCV; in particular, it was double blind in the sense that the authors did not know the name of the reviewers and vice versa. Furthermore, each conference submission was held confidentially, and was only publicly revealed if and once accepted for publication. Each paper received at least three reviews, totalling more than 15,000 reviews. Handling the review process at this scale was a significant challenge. In order to ensure that each submission received as fair and high-quality reviews as possible, we recruited 2,830 reviewers (a 130% increase with reference to 2018) and 207 area chairs (a 60% increase). The area chairs were selected based on their technical expertise and reputation, largely among people that served as area chair in previous top computer vision and machine learning conferences (ECCV, ICCV, CVPR, NeurIPS, etc.). Reviewers were similarly invited from previous conferences. We also encouraged experienced area chairs to suggest additional chairs and reviewers in the initial phase of recruiting.

Despite doubling the number of submissions, the reviewer load was slightly reduced from 2018, from a maximum of 8 papers down to 7 (with some reviewers offering to handle 6 papers plus an emergency review). The area chair load increased slightly, from 18 papers on average to 22 papers on average.

Conflicts of interest between authors, area chairs, and reviewers were handled largely automatically by the Open Review platform via their curated list of user profiles. Many authors submitting to ECCV already had a profile in Open Review. We set a paper registration deadline one week before the paper submission deadline in order to encourage all missing authors to register and create their Open Review profiles well on time (in practice, we allowed authors to create/change papers arbitrarily until the submission deadline). Except for minor issues with users creating duplicate profiles, this allowed us to easily and quickly identify institutional conflicts, and avoid them, while matching papers to area chairs and reviewers.

Papers were matched to area chairs based on: an affinity score computed by the Open Review platform, which is based on paper titles and abstracts, and an affinity

score computed by the Toronto Paper Matching System (TPMS), which is based on the paper's full text, the area chair bids for individual papers, load balancing, and conflict avoidance. Open Review provides the program chairs a convenient web interface to experiment with different configurations of the matching algorithm. The chosen configuration resulted in about 50% of the assigned papers to be highly ranked by the area chair bids, and 50% to be ranked in the middle, with very few low bids assigned.

Assignments to reviewers were similar, with two differences. First, there was a maximum of 7 papers assigned to each reviewer. Second, area chairs recommended up to seven reviewers per paper, providing another highly-weighted term to the affinity scores used for matching.

The assignment of papers to area chairs was smooth. However, it was more difficult to find suitable reviewers for all papers. Having a ratio of 5.6 papers per reviewer with a maximum load of 7 (due to emergency reviewer commitment), which did not allow for much wiggle room in order to also satisfy conflict and expertise constraints. We received some complaints from reviewers who did not feel qualified to review specific papers and we reassigned them wherever possible. However, the large scale of the conference, the many constraints, and the fact that a large fraction of such complaints arrived very late in the review process made this process very difficult and not all complaints could be addressed.

Reviewers had six weeks to complete their assignments. Possibly due to COVID-19 or the fact that the NeurIPS deadline was moved closer to the review deadline, a record 30% of the reviews were still missing after the deadline. By comparison, ECCV 2018 experienced only 10% missing reviews at this stage of the process. In the subsequent week, area chairs chased the missing reviews intensely, found replacement reviewers in their own team, and managed to reach 10% missing reviews. Eventually, we could provide almost all reviews (more than 99.9%) with a delay of only a couple of days on the initial schedule by a significant use of emergency reviews. If this trend is confirmed, it might be a major challenge to run a smooth review process in future editions of ECCV. The community must reconsider prioritization of the time spent on paper writing (the number of submissions increased a lot despite COVID-19) and time spent on paper reviewing (the number of reviews delivered in time decreased a lot presumably due to COVID-19 or NeurIPS deadline). With this imbalance the peer-review system that ensures the quality of our top conferences may break soon.

Reviewers submitted their reviews independently. In the reviews, they had the opportunity to ask questions to the authors to be addressed in the rebuttal. However, reviewers were told not to request any significant new experiment. Using the Open Review interface, authors could provide an answer to each individual review, but were also allowed to cross-reference reviews and responses in their answers. Rather than PDF files, we allowed the use of formatted text for the rebuttal. The rebuttal and initial reviews were then made visible to all reviewers and the primary area chair for a given paper. The area chair encouraged and moderated the reviewer discussion. During the discussions, reviewers were invited to reach a consensus and possibly adjust their ratings as a result of the discussion and of the evidence in the rebuttal.

After the discussion period ended, most reviewers entered a final rating and recommendation, although in many cases this did not differ from their initial recommendation. Based on the updated reviews and discussion, the primary area chair then

made a preliminary decision to accept or reject the paper and wrote a justification for it (meta-review). Except for cases where the outcome of this process was absolutely clear (as indicated by the three reviewers and primary area chairs all recommending clear rejection), the decision was then examined and potentially challenged by a secondary area chair. This led to further discussion and overturning a small number of preliminary decisions. Needless to say, there was no in-person area chair meeting, which would have been impossible due to COVID-19.

Area chairs were invited to observe the consensus of the reviewers whenever possible and use extreme caution in overturning a clear consensus to accept or reject a paper. If an area chair still decided to do so, she/he was asked to clearly justify it in the meta-review and to explicitly obtain the agreement of the secondary area chair. In practice, very few papers were rejected after being confidently accepted by the reviewers.

This was the first time Open Review was used as the main platform to run ECCV. In 2018, the program chairs used CMT3 for the user-facing interface and Open Review internally, for matching and conflict resolution. Since it is clearly preferable to only use a single platform, this year we switched to using Open Review in full. The experience was largely positive. The platform is highly-configurable, scalable, and open source. Being written in Python, it is easy to write scripts to extract data programmatically. The paper matching and conflict resolution algorithms and interfaces are top-notch, also due to the excellent author profiles in the platform. Naturally, there were a few kinks along the way due to the fact that the ECCV Open Review configuration was created from scratch for this event and it differs in substantial ways from many other Open Review conferences. However, the Open Review development and support team did a fantastic job in helping us to get the configuration right and to address issues in a timely manner as they unavoidably occurred. We cannot thank them enough for the tremendous effort they put into this project.

Finally, we would like to thank everyone involved in making ECCV 2020 possible in these very strange and difficult times. This starts with our authors, followed by the area chairs and reviewers, who ran the review process at an unprecedented scale. The whole Open Review team (and in particular Melisa Bok, Mohit Unyal, Carlos Mondragon Chapa, and Celeste Martinez Gomez) worked incredibly hard for the entire duration of the process. We would also like to thank René Vidal for contributing to the adoption of Open Review. Our thanks also go to Laurent Charling for TPMS and to the program chairs of ICML, ICLR, and NeurIPS for cross checking double submissions. We thank the website chair, Giovanni Farinella, and the CPI team (in particular Ashley Cook, Miriam Verdon, Nicola McGrane, and Sharon Kerr) for promptly adding material to the website as needed in the various phases of the process. Finally, we thank the publication chairs, Albert Ali Salah, Hamdi Dibeklioglu, Metehan Doyran, Henry Howard-Jenkins, Victor Prisacariu, Siyu Tang, and Gul Varol, who managed to compile these substantial proceedings in an exceedingly compressed schedule. We express our thanks to the ECVA team, in particular Kristina Scherbaum for allowing open access of the proceedings. We thank Alfred Hofmann from Springer who again

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August 2020

Andrea Vedaldi
Horst Bischof
Thomas Brox
Jan-Michael Frahm

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Philippe Bekaert	Toby P. Breckon	Lluís Castrejon
Esube Bekele	Francois Bremond	Jacopo Cavazza
Vasileios Belagiannis	Jesus Briaies	Fabio Cermelli
Ohad Ben-Shahar	Sofia Broomé	Hakan Cevikalp
Abhijit Bendale	Marcus A. Brubaker	Menglei Chai
Róger Bermúdez-Chacón	Luc Brun	Ishani Chakraborty
Maxim Berman	Silvia Bucci	Rudrasis Chakraborty
Jesus Bermudez-cameo	Shyamal Buch	Antoni B. Chan

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Siddhartha Chandra	Weikai Chen	Tim Cho
Sharat Chandran	Xi Chen	Tae Eun Choe
Arjun Chandrasekaran	Xiaohan Chen	Chiho Choi
Angel X. Chang	Xiaozhi Chen	Edward Choi
Che-Han Chang	Xilin Chen	Inchang Choi
Hong Chang	Xingyu Chen	Jinsoo Choi
Hyun Sung Chang	Xinlei Chen	Jonghyun Choi
Hyung Jin Chang	Xinyun Chen	Jongwon Choi
Jianlong Chang	Yi-Ting Chen	Yukyung Choi
Ju Yong Chang	Yilun Chen	Hisham Cholakkal
Ming-Ching Chang	Ying-Cong Chen	Eunji Chong
Simyung Chang	Yinpeng Chen	Jaegul Choo
Xiaojun Chang	Yiran Chen	Christopher Choy
Yu-Wei Chao	Yu Chen	Hang Chu
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Arslan Chaudhry	Yuhua Chen	Wen-Sheng Chu
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Can Chen	Yunpeng Chen	Joon Son Chung
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Chao Chen	Zhuoyuan Chen	Safa Cicek
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Dapeng Chen	Bowen Cheng	Javier Civera
Dong Chen	Erkang Cheng	James J. Clark
Dongdong Chen	Gong Cheng	Ronald Clark
Guanying Chen	Guangliang Cheng	Felipe Codevilla
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Hsin-yi Chen	Jun Cheng	Andrea Cohen
Huaijin Chen	Li Cheng	Maxwell D. Collins
Hwann-Tzong Chen	Ming-Ming Cheng	Carlo Colombo
Jianbo Chen	Yu Cheng	Yang Cong
Jianhui Chen	Ziang Cheng	Adria R. Contente
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Jiaxin Chen	Dmitry Chetverikov	John Richard Corring
Jie Chen	Ngai-man Cheung	Darren Cosker
Jun-Cheng Chen	William Cheung	Dragos Costea
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Lin Chen	Benjamin Chidester	Marco Cristani
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Min-Hung Chen	Mang Tik Chiu	James L. Crowley
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Shi Chen	Donghyeon Cho	Zhaopeng Cui
Shixing Chen	Hojin Cho	Ross Cutler
Tianshui Chen	Minsu Cho	Antonio D'Innocente

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Dengxin Dai	Zhengming Ding	Francisco Escolano
Hang Dai	Robert DiPietro	Victor Escorcia
Longquan Dai	Cosimo Distante	Carlos Esteves
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Yuchao Dai	Abdelaziz Djelouah	Chenyong Fan
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Bharath B. Damodaran	Bo Dong	Hehe Fan
Kristin Dana	Chao Dong	Heng Fan
Martin Danelljan	Jiangxin Dong	Kai Fan
Zheng Dang	Weiming Dong	Lijie Fan
Zachary Alan Daniels	Weisheng Dong	Linxi Fan
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Abhishek Das	Xuanyi Dong	Shaojing Fan
Samyak Datta	Yinpeng Dong	Xiaochuan Fan
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Titas De	Hazel Doughty	Yuchen Fan
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Shalini De Mello	Ye Duan	Kuan Fang
Joseph DeGol	Yueqi Duan	Yi Fang
Herve Delingette	Abhimanyu Dubey	Yuming Fang
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Jiankang Deng	Stefan Duffner	Alireza Fathi
Weijian Deng	Chi Nhan Duong	Raanan Fattal
Zhiwei Deng	Thibaut Durand	Joao Fayad
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Konstantinos G. Derpanis	Iulia Duta	Christoph Feichtenhofer
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Somdip Dey	Marc Eder	Jiashi Feng
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Abhinav Dhall	Alexei A. Efros	Mengyang Feng
Helisa Dharmo	Kiana Ehsani	Qianli Feng
Vikas Dhiman	Hazm Kemal Ekenel	Zhenhua Feng
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de Souza	Mohamed Elgharib	Andras Ferencz
Ali Diba	Shireen Elhabian	Martin Fergie
Ferran Diego	Ehsan Elhamifar	Basura Fernando
Guiguang Ding	Mohamed Elhoseiny	Ethan Fetaya
Henghui Ding	Ian Endres	Michael Firman
Jian Ding	N. Benjamin Erichson	John W. Fisher

Matthew Fisher	Jin Gao	Dong Gong
Boris Flach	Jiyang Gao	Ke Gong
Corneliu Florea	Junbin Gao	Mingming Gong
Wolfgang Foerstner	Katelyn Gao	Abel Gonzalez-Garcia
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Gian Luca Foresti	Mingfei Gao	Daniel Gordon
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Katerina Fragkiadaki	Shenghua Gao	Ankit Goyal
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Ohad Fried	Noa Garcia	Benjamin Graham
Iuri Frosio	Alberto Garcia-Garcia	Douglas Gray
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Huazhu Fu	Garcia-Hernando	Etienne Grossmann
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Jingjing Fu	Animesh Garg	Jiayuan Gu
Xueyang Fu	Kshitiz Garg	Jiuxiang Gu
Yanwei Fu	Rahul Garg	Lin Gu
Ying Fu	Ravi Garg	Qiao Gu
Yun Fu	Philip N. Garner	Shuhang Gu
Olac Fuentes	Kirill Gavriluk	Jose J. Guerrero
Kent Fujiwara	Paul Gay	Paul Guerrero
Takuya Funatomi	Shiming Ge	Jie Gui
Christopher Funk	Weifeng Ge	Jean-Yves Guillemaut
Thomas Funkhouser	Baris Gecer	Riza Alp Guler
Antonino Furnari	Xin Geng	Erhan Gundogdu
Ryo Furukawa	Kyle Genova	Fatma Guney
Erik Gärtner	Stamatios Georgoulis	Guodong Guo
Raghudeep Gadde	Bernard Ghanem	Kaiwen Guo
Matheus Gadelha	Michael Gharbi	Qi Guo
Vandit Gajjar	Kamran Ghasedi	Sheng Guo
Trevor Gale	Golnaz Ghiasi	Shi Guo
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Mathias Gallardo	Partha Ghosh	Xiaojie Guo
Guillermo Gallego	Silvio Giancola	Yijie Guo
Orazio Gallo	Andrew Gilbert	Yiluan Guo
Chuang Gan	Rohit Girdhar	Yuanfang Guo
Zhe Gan	Xavier Giro-i-Nieto	Yulan Guo
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Aditya Ganeshan	Ioannis Gkioulekas	Ankush Gupta
Siddha Ganju	Clement Godard	Mohit Gupta
Bin-Bin Gao	Vaibhava Goel	Saurabh Gupta
Changxin Gao	Bastian Goldluecke	Tanmay Gupta
Feng Gao	Lluis Gomez	Danna Gurari
Hongchang Gao	Nuno Gonçaves	Abner Guzman-Rivera

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Michael Gygli	Chinmay Hegde	Xiaowei Hu
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Emanuela Haller	Roei Herzig	Dong Huang
Stefan Haller	Anders Heyden	Fay Huang
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Abdullah Hamdi	Otmar Hilliges	Haozhi Huang
Dongyoon Han	Tomas Hodan	Heng Huang
Hu Han	Judy Hoffman	Huaibo Huang
Jungong Han	Michael Hofmann	Jia-Bin Huang
Junwei Han	Yannick Hold-Geoffroy	Jing Huang
Kai Han	Namdar Homayounfar	Jingwei Huang
Tian Han	Sina Honari	Kaizhu Huang
Xiaoguang Han	Richang Hong	Lei Huang
Xintong Han	Seunghoon Hong	Qiangui Huang
Yahong Han	Xiaopeng Hong	Qiaoying Huang
Ankur Handa	Yi Hong	Qingqiu Huang
Zekun Hao	Hidekata Hontani	Qixing Huang
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Mehrtash Harandi	Mir Rayat Imtiaz Hossain	Siyuan Huang
Adam W. Harley	Junhui Hou	Weilin Huang
Mahmudul Hasan	Le Hou	Wenbing Huang
Atsushi Hashimoto	Lu Hou	Xiangru Huang
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Munawar Hayat	Wei-Lin Hsiao	Yan Huang
Dongliang He	Cheng-Chun Hsu	Yifei Huang
Jingrui He	Gee-Sern Jison Hsu	Yue Huang
Junfeng He	Kuang-jui Hsu	Zhiwu Huang
Kaiming He	Changbo Hu	Zilong Huang
Kun He	Di Hu	Minyoung Huh
Lei He	Guosheng Hu	Zhuo Hui
Pan He	Han Hu	Matthias B. Hullin
Ran He	Hao Hu	Martin Humenberger
Shengfeng He	Hexiang Hu	Wei-Chih Hung
Tong He	Hou-Ning Hu	Zhouyuan Huo
Weipeng He	Jie Hu	Junhwa Hur
Xuming He	Junlin Hu	Noureddien Hussein
Yang He	Nan Hu	Jyh-Jing Hwang
Yihui He	Ping Hu	Seong Jae Hwang

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Ichiro Ide	Li Jiang	Kenichi Kanatani
Ivo Ihrke	Lu Jiang	Angjoo Kanazawa
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Satoshi Ikehata	Peng Jiang	Takuhiro Kaneko
Nazli Ikizler-Cinbis	Shuqiang Jiang	Asako Kanezaki
Sunghoon Im	Wei Jiang	Bingyi Kang
Yani Ioannou	Xudong Jiang	Di Kang
Radu Tudor Ionescu	Zhuolin Jiang	Sunghun Kang
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Go Irie	Zequn Jie	Vadim Kantorov
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Md Amirul Islam	Kyong Hwan Jin	Amlan Kar
Vamsi Ithapu	Lianwen Jin	Theofanis Karaletsos
Nathan Jacobs	SouYoung Jin	Leonid Karlinsky
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Himalaya Jain	Xin Jin	Angelos Katharopoulos
Suyog Jain	Nebojsa Jojic	Isinsu Katircioglu
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Won-Dong Jang	Michael Jeffrey Jones	Zoltan Kato
Yunseok Jang	Hanbyul Joo	Dotan Kaufman
Ronnachai Jaroensri	Jungseock Joo	Jan Kautz
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Sadeep Jayasumana	Ajjen Joshi	Qihong Ke
Suren Jayasuriya	Shantanu H. Joshi	Wadim Kehl
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Yunho Jeon	Asim Kadav	Margret Keuper
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I-hong Jhuo	Dagmar Kainmueller	Fahad Khan
Dinghuang Ji	Ioannis A. Kakadiaris	Naemullah Khan
Hui Ji	Zdenek Kalal	Salman Khan
Jingwei Ji	Nima Kalantari	Siddhesh Khandelwal
Pan Ji	Yannis Kalantidis	Rawal Khirodkar
Yanli Ji	Mahdi M. Kalayeh	Anna Khoreva
Baoxiong Jia	Anmol Kalia	Tejas Khot
Kui Jia	Sinan Kalkan	Parmeshwar Khurd
Xu Jia	Vicky Kalogeiton	Hadi Kiapour
Chiyu Max Jiang	Ashwin Kalyan	Joe Kileel
Haiyong Jiang	Joni-kristian Kamarainen	Chanho Kim
Hao Jiang	Gerda Kamberova	Dahun Kim
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Huajie Jiang	Martin Kampel	Eunwoo Kim
Ke Jiang	Meina Kan	Han-ul Kim

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Heewon Kim	Jana Kosecka	Xu Lan
Hyo Jin Kim	Jean Kossaifi	Charis Lanaras
Hyunwoo J. Kim	Satwik Kottur	Georg Langs
Jinkyu Kim	Rigas Kouskouridas	Oswald Lanz
Jiwon Kim	Adriana Kovashka	Dong Lao
Jongmin Kim	Rama Kovvuri	Yizhen Lao
Junsik Kim	Adarsh Kowdle	Agata Lapedriza
Junyeong Kim	Jedrzey Kozerawski	Gustav Larsson
Min H. Kim	Mateusz Kozinski	Viktor Larsson
Namil Kim	Philipp Kraehenbuehl	Katrin Lasinger
Pyojin Kim	Gregory Kramida	Christoph Lassner
Seon Joo Kim	Josip Krapac	Longin Jan Latecki
Seong Tae Kim	Dmitry Kravchenko	Stéphane Lathuilière
Seungryong Kim	Ranjay Krishna	Rynson Lau
Sungwoong Kim	Pavel Krsek	Hei Law
Tae Hyun Kim	Alexander Krull	Justin Lazarow
Vladimir Kim	Jakob Kruse	Svetlana Lazebnik
Won Hwa Kim	Hiroyuki Kubo	Hieu Le
Yonghyun Kim	Hilde Kuehne	Huu Le
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Akisato Kimura	Andreas Kuhn	Trung-Nghia Le
Pieter-Jan Kindermans	Arjan Kuijper	Vuong Le
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Itaru Kitahara	Ajay Kumar	Erik Learned-Miller
Hedvig Kjellstrom	Amit Kumar	Chen-Yu Lee
Jan Knopp	Avinash Kumar	Kim Hee Lee
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Erich Kobler	Vijay Kumar	Hyungtae Lee
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Reinhard Koch	Weicheng Kuo	Jimmy Addison Lee
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Amir Kolaman	Suha Kwak	Kibok Lee
Nicholas Kolkin	Junseok Kwon	Kuang-Huei Lee
Dimitrios Kollias	Nikolaos Kyriazis	Kwonjoon Lee
Stefanos Kollias	Zorah Lähler	Minsik Lee
Soheil Kolouri	Ankit Laddha	Sang-chul Lee
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Naejin Kong	Jean Lahoud	Soochan Lee
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Tao Kong	Shang-Hong Lai	Taehee Lee
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Daniil Kononenko	Iro Laina	Peng Lei
Theodora Kontogianni	Antony Lam	Matthew Joseph Leotta
Simon Korman	John Wheatley Lambert	Wee Kheng Leow

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Evgeny Levinkov	Shiwei Li	Shengcai Liao
Aviad Levis	Shuang Li	Shuai Liao
Jose Lezama	Siyang Li	Yiyi Liao
Ang Li	Stan Z. Li	Ser-Nam Lim
Bin Li	Tianye Li	Chen-Hsuan Lin
Bing Li	Wei Li	Chung-Ching Lin
Boyi Li	Weixin Li	Dahua Lin
Changsheng Li	Wen Li	Ji Lin
Chao Li	Wenbo Li	Kevin Lin
Chen Li	Xiaomeng Li	Tianwei Lin
Cheng Li	Xin Li	Tsung-Yi Lin
Chenglong Li	Xiu Li	Tsung-Yu Lin
Chi Li	Xuelong Li	Wei-An Lin
Chun-Guang Li	Xueting Li	Weiyao Lin
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Chunyuan Li	Yandong Li	Yuewei Lin
Dong Li	Yanghao Li	David B. Lindell
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Hao Li	Yi Li	Krzysztof Lis
Haoxiang Li	Yijun Li	Roe Litman
Hongsheng Li	Yikang Li	Jim Little
Hongyang Li	Yining Li	An-An Liu
Houqiang Li	Yongjie Li	Bo Liu
Huibin Li	Yu Li	Buyu Liu
Jia Li	Yu-Jhe Li	Chao Liu
Jianan Li	Yunpeng Li	Chen Liu
Jianguo Li	Yunsheng Li	Cheng-lin Liu
Junnan Li	Yunzhu Li	Chenxi Liu
Junxuan Li	Zhe Li	Dong Liu
Kai Li	Zhen Li	Feng Liu
Ke Li	Zhengqi Li	Guilin Liu
Kejie Li	Zhenyang Li	Haomiao Liu
Kunpeng Li	Zhuwen Li	Heshan Liu
Lerenhan Li	Dongze Lian	Hong Liu
Li Erran Li	Xiaochen Lian	Ji Liu
Mengtian Li	Zhouhui Lian	Jingen Liu
Mu Li	Chen Liang	Jun Liu
Peihua Li	Jie Liang	Lanlan Liu
Peiyi Li	Ming Liang	Li Liu
Ping Li	Paul Pu Liang	Liu Liu
Qi Li	Pengpeng Liang	Mengyuan Liu
Qing Li	Shu Liang	Miaomiao Liu
Ruiyu Li	Wei Liang	Nian Liu
Ruoteng Li	Jing Liao	Ping Liu
Shaozi Li	Minghui Liao	Risheng Liu

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Shu Liu	Charles T. Loop	Ke Ma
Shuaicheng Liu	Antonio Lopez	Lin Ma
Sifei Liu	Roberto J. Lopez-Sastre	Liqian Ma
Siqi Liu	Javier Lorenzo-Navarro	Shugao Ma
Siyang Liu	Manolis Lourakis	Wei-Chiu Ma
Songtao Liu	Boyu Lu	Xiaojian Ma
Ting Liu	Canyi Lu	Xingjun Ma
Tongliang Liu	Feng Lu	Zhanyu Ma
Tyng-Luh Liu	Guoyu Lu	Zheng Ma
Wanquan Liu	Hongtao Lu	Radek Jakob Mackowiak
Wei Liu	Jiajun Lu	Ludovic Magerand
Weiyang Liu	Jiasen Lu	Shweta Mahajan
Weizhe Liu	Jiwen Lu	Siddharth Mahendran
Wenyu Liu	Kaiyue Lu	Long Mai
Wu Liu	Le Lu	Ameesh Makadia
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Xianglong Liu	Shijian Lu	Mateusz Malinowski
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Xiaofeng Liu	Xin Lu	Arun Mallya
Xihui Liu	Yao Lu	Dipu Manandhar
Xingyu Liu	Yiping Lu	Massimiliano Mancini
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Xuanqing Liu	Yongyi Lu	Kevis-kokitsi Maninis
Xuebo Liu	Zhiwu Lu	Varun Manjunatha
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Yaojie Liu	Benjamin E. Lundell	Xudong Mao
Yebin Liu	Hao Luo	Alina Marcu
Yen-Cheng Liu	Jian-Hao Luo	Edgar Margffoy-Tuay
Yiming Liu	Ruotian Luo	Dmitrii Marin
Yu Liu	Weixin Luo	Manuel J. Marin-Jimenez
Yu-Shen Liu	Wenhan Luo	Kenneth Marino
Yufan Liu	Wenjie Luo	Niki Martinel
Yun Liu	Yan Luo	Julieta Martinez
Zheng Liu	Zelun Luo	Jonathan Masci
Zhijian Liu	Zixin Luo	Tomohiro Mashita
Zhuang Liu	Khoa Luu	Iacopo Masi
Zichuan Liu	Zhaoyang Lv	David Masip
Ziwei Liu	Pengyuan Lyu	Daniela Massiceti
Zongyi Liu	Thomas Möllenhoff	Stefan Mathe
Stephan Liwicki	Matthias Müller	Yusuke Matsui
Liliana Lo Presti	Bingpeng Ma	Tetsu Matsukawa
Chengjiang Long	Chih-Yao Ma	Iain A. Matthews
Fuchen Long	Chongyang Ma	Kevin James Matzen
Mingsheng Long	Huimin Ma	Bruce Allen Maxwell
Xiang Long	Jiayi Ma	Stephen Maybank

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Amir Mazaheri	Pavlo Molchanov	Neda Nategh
David McAllester	Davide Moltisanti	Nelson Isao Nauata
Steven McDonagh	Pascal Monasse	Fernando Navarro
Stephen J. Mckenna	Mathew Monfort	Shah Nawaz
Roey Mechrez	Aron Monszpart	Lukas Neumann
Prakhar Mehrotra	Sean Moran	Ram Nevatia
Christopher Mei	Vlad I. Morariu	Alejandro Newell
Xue Mei	Francesc Moreno-Noguer	Shawn Newsam
Paulo R. S. Mendonca	Pietro Morerio	Joe Yue-Hei Ng
Lili Meng	Stylianos Moschoglou	Trung Thanh Ngo
Zibo Meng	Yael Moses	Duc Thanh Nguyen
Thomas Mensink	Roozbeh Mottaghi	Lam M. Nguyen
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Kourosh Meshgi	Yadong Mu	Mihalis Nicolaou
Pascal Mettes	Yasuhiro Mukaigawa	Andrei Liviu Nicolicioiu
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Liang Mi	Yusuke Mukuta	Michael Niemeyer
Qiguang Miao	Ravi Teja Mullapudi	Simon Niklaus
Xin Miao	Mario Enrique Munich	Christophoros Nikou
Tomer Michaeli	Zachary Murez	David Nilsson
Frank Michel	Ana C. Murillo	Jifeng Ning
Antoine Miech	J. Krishna Murthy	Yuval Nirkin
Krystian Mikolajczyk	Damien Muselet	Li Niu
Peyman Milanfar	Armin Mustafa	Yuzhen Niu
Ben Mildenhall	Siva Karthik Mustikovela	Zhenxing Niu
Gregor Miller	Carlo Dal Mutto	Shohei Nobuhara
Fausto Milletari	Moin Nabi	Nicoletta Noceti
Dongbo Min	Varun K. Nagaraja	Hyeonwoo Noh
Kyle Min	Tushar Nagarajan	Junhyug Noh
Pedro Miraldo	Arsha Nagrani	Mehdi Noroozi
Dmytro Mishkin	Seungjun Nah	Sotiris Nousias
Anand Mishra	Nikhil Naik	Valsamis Ntouskos
Ashish Mishra	Yoshikatsu Nakajima	Matthew O'Toole
Ishan Misra	Yuta Nakashima	Peter Ochs
Niluthpol C. Mithun	Atsushi Nakazawa	Ferda Ofli
Kaushik Mitra	Seonghyeon Nam	Seong Joon Oh
Niloy Mitra	Vinay P. Namboodiri	Seoung Wug Oh
Anton Mitrokhin	Medhini Narasimhan	Iason Oikonomidis
Ikuhisa Mitsugami	Srinivasa Narasimhan	Utkarsh Ojha
Anurag Mittal	Sanath Narayan	Takahiro Okabe
Kaichun Mo	Erickson Rangel	Takayuki Okatani
Zhipeng Mo	Nascimento	Fumio Okura
Davide Modolo	Jacinto Nascimento	Aude Oliva
Michael Moeller	Tayyab Naseer	Kyle Olszewski

Björn Ommer	Nikolaos Passalis	Daniel Pizarro
Mohamed Omran	Vishal Patel	Tobias Plötz
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Michael Opitz	Badri Narayana Patro	Matteo Poggi
Jose Oramas	Danda Pani Paudel	Moacir A. Ponti
Tribhuvanesh Orekondy	Sujoy Paul	Parita Pooj
Shaul Oron	Georgios Pavlakos	Fatih Porikli
Sergio Orts-Escolano	Ioannis Pavlidis	Horst Possegger
Ivan Oseledets	Vladimir Pavlovic	Omid Poursaeed
Aljosa Osep	Nick Pears	Ameya Prabhu
Magnus Oskarsson	Kim Steenstrup Pedersen	Viraj Uday Prabhu
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Martin R. Oswald	Shmuel Peleg	Brian L. Price
Wanli Ouyang	Chao Peng	True Price
Andrew Owens	Houwen Peng	Maria Priisalu
Mete Ozay	Wen-Hsiao Peng	Veronique Prinnet
Mustafa Ozuysal	Xi Peng	Victor Adrian Prisacariu
Eduardo Pérez-Pellitero	Xiaojiang Peng	Jan Prokaj
Gautam Pai	Xingchao Peng	Sergey Prokudin
Dipan Kumar Pal	Yuxin Peng	Nicolas Pugeault
P. H. Pamplona Savarese	Federico Perazzi	Xavier Puig
Jinshan Pan	Juan Camilo Perez	Albert Pumarola
Junting Pan	Vishwanath Peri	Pulak Purkait
Xingang Pan	Federico Pernici	Senthil Purushwalkam
Yingwei Pan	Luca Del Pero	Charles R. Qi
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