## 2022 IEEE/ACM 44th International Conference on Software Engineering (ICSE 2022)

Pittsburgh, Pennsylvania, USA 22-27 May 2022

Pages 1-622



**IEEE Catalog Number: ISBN:** 

CFP22018-POD 978-1-6654-9589-9

### Copyright © 2022, Association for Computing Machinery (ACM) **All Rights Reserved**

\*\*\* This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.

IEEE Catalog Number: CFP22018-POD ISBN (Print-On-Demand): 978-1-6654-9589-9 ISBN (Online): 978-1-4503-9221-1

ISSN: 0270-5257

#### Additional Copies of This Publication Are Available From:

Curran Associates, Inc 57 Morehouse Lane Red Hook, NY 12571 USA Phone: (845) 758-0400

Fax:

(845) 758-2633 curran@proceedings.com E-mail: Web: www.proceedings.com



# 2022 IEEE/ACM 44th International Conference on Software Engineering (ICSE) ICSE 2022

## **Table of Contents**

Message from the ICSE 2022 General Chair	
Message from the Program Chairs of ICSE 2022	
Organizing Committee ICSE 2022	xxxiii
Message from the Workshop Chairs of ICSE 2022	
ICSE 2022 Workshop Program Committee	
Message from the Journal-First Track Chairs	
Journal-First Program Committee	
Sponsors and Supporters	xlvi
2022 IEEE/ACM 44th International Conference on Software Engi (ICSE)	neering
µAFL: Non-Intrusive Feedback-Driven Fuzzing for Microcontroller Firmware	1
A Grounded Theory Based Approach to Characterize Software Attack Surfaces	13
A Grounded Theory of Coordination in Remote-First and Hybrid Software Teams	25
A Scalable t-wise Coverage Estimator	36

A Universal Data Augmentation Approach for Fault Localization
Adaptive Performance Anomaly Detection for Online Service Systems via Pattern Sketching
Adaptive Test Selection for Deep Neural Networks
An Exploratory Study of Deep Learning Supply Chain
An Exploratory Study of Productivity Perceptions in Software Teams
Analyzing User Perspectives on Mobile App Privacy at Scale
Aper: Evolution-Aware Runtime Permission Misuse Detection for Android Apps
ARCLIN: Automated API Mention Resolution for Unformatted Texts

AST-Trans: Code Summarization with Efficient Tree-Structured Attention	150
Automated Assertion Generation via Information Retrieval and Its Integration with Deep Learning	163
Hao Yu (Peking University, China), Yiling Lou (Purdue University, USA), Ke Sun (Peking University, China), Dezhi Ran (Peking University, China), Tao Xie (Peking University, China), Dan Hao (Peking University, China), Ying Li (Peking University, China), Ge Li (Peking University, China), and Qianxiang Wang (Huawei Technologies CO., LTD., China)	
Automated Detection of Password Leakage from Public GitHub Repositories	175
Automated Handling of Anaphoric Ambiguity in Requirements: A Multi-Solution Study  Saad Ezzini (University of Luxembourg, Luxembourg), Sallam Abualhaija (University of Luxembourg, Luxembourg), Chetan Arora (Deakin University, Australia), and Mehrdad Sabetzadeh (University of Ottawa, Canada)	187
Automated Patching for Unreproducible Builds	200
Automated Testing of Software that Uses Machine Learning APIs  Chengcheng Wan (University of Chicago), Shicheng Liu (University of Chicago), Sophie Xie (Whitney Young High School), Yifan Liu (University of Chicago), Henry Hoffmann (University of Chicago), Michael Maire (University of Chicago), and Shan Lu (University of Chicago)	212
Automatic Detection of Performance Bugs in Database Systems Using Equivalent Queries  Xinyu Liu (Georgia Institute of Technology, USA), Qi Zhou (Meta, USA),  Joy Arulraj (Georgia Institute of Technology, USA), and Alessandro  Orso (Georgia Institute of Technology, USA)	225
AutoTransform: Automated Code Transformation to Support Modern Code Review Process  Patanamon Thongtanunam (The University of Melbourne, Australia),  Chanathip Pornprasit (Monash University, Australia), and Chakkrit  Tantithamthavorn (Monash University, Australia)	237
BeDivFuzz: Integrating Behavioral Diversity into Generator-Based Fuzzing	249

Big Data = Big Insights? Operationalising Brooks' Law in a Massive GitHub Data Set	. 262
Bots for Pull Requests: The Good, the Bad, and the Promising	274
Bridging Pre-Trained Models and Downstream Tasks for Source Code Understanding	287
BugListener: Identifying and Synthesizing Bug Reports from Collaborative Live Chats	299
BuildSheriff: Change-Aware Test Failure Triage for Continuous Integration Builds	. 312
Causality in Configurable Software Systems	325
Causality-Based Neural Network Repair  Bing Sun (Singapore Management University, Singapore), Jun Sun (Singapore Management University, Singapore), H. Long Pham (Singapore Management University, Singapore), and Jie Shi (Huawei, Singapore)	338
Change Is the Only Constant: Dynamic Updates for Workflows	. 350

Characterizing and Detecting Bugs in WeChat Mini-Programs	. 363
Tao Wang (Institute of Software, Chinese Academy of Sciences, University of Chinese Academy of Sciences, China), Qingxin Xu (Institute of Software, Chinese Academy of Sciences, University of Chinese Academy of Sciences, China), Xiaoning Chang (Institute of Software, Chinese Academy of Sciences, University of Chinese Academy of Sciences, China), Wensheng Dou (Institute of Software, Chinese Academy of Sciences, University of Chinese Academy of Sciences, China), Jiaxin Zhu (Institute of Software, Chinese Academy of Sciences, University of Chinese Academy of Sciences, China), Jinhui Xie (Tencent, Inc., China), Yuetang Deng (Tencent, Inc., China), Jianbo Yang (Tencent, Inc., China), Jiaheng Yang (Tencent, Inc., China), Jun Wei (Institute of Software, Chinese Academy of Sciences, University of Chinese Academy of Sciences, China), and Tao Huang (Institute of Software, Chinese Academy of Sciences, University of	. 300
Chinese Academy of Sciences, China)	
CLEAR: Contrastive Learning for API Recommendation	. 376
Code Search Based on Context-Aware Code Translation	388
CodeFill: Multi-token Code Completion by Jointly Learning from Structure and Naming	
Sequences	401
Collaboration Challenges in Building ML-Enabled Systems: Communication, Documentation,	
Engineering, and Process  Nadia Nahar (Carnegie Mellon University, USA), Shurui Zhou (University of Toronto, Canada), Grace Lewis (Carnegie Mellon Software Engineering Institute, USA), and Christian Kästner (Carnegie Mellon University, USA)	. 413
Combinatorial Testing of RESTful APIs	. 426
CONFETTI: Amplifying Concolic Guidance for Fuzzers	. 438
James Kukucka (George Mason University, USA), Luís Pina (University of Illinois Chicago, USA), Paul Ammann (George Mason University, USA), and Jonathan Bell (Northeastern University, USA)	

Conflict-Aware Inference of Python Compatible Runtime Environments with Domain Knowledge Graph
Control Parameters Considered Harmful: Detecting Range Specification Bugs in Drone Configuration Modules via Learning-Guided Search
Controlled Concurrency Testing via Periodical Scheduling
Cross-Domain Deep Code Search with Meta Learning
Data-Driven Loop Bound Learning for Termination Analysis
DEAR: A Novel Deep Learning-Based Approach for Automated Program Repair
Decomposing Convolutional Neural Networks into Reusable and Replaceable Modules
Decomposing Software Verification into Off-the-Shelf Components: An Application to CEGAR 536 Dirk Beyer (LMU Munich, Germany), Jan Haltermann (University of Oldenburg, Germany), Thomas Lemberger (LMU Munich, Germany), and Heike Wehrheim (University of Oldenburg, Germany)
DeepAnalyze: Learning to Localize Crashes at Scale
DeepDiagnosis: Automatically Diagnosing Faults and Recommending Actionable Fixes in Deep Learning Programs

DeepFD: Automated Fault Diagnosis and Localization for Deep Learning Programs  Jialun Cao (The Hong Kong University of Science and Technology and  Guangzhou HKUST Fok Ying Tung Research Institute, China), Meiziniu Li  (The Hong Kong University of Science and Technology, China), Xiao Chen  (Huazhong University of Science and Technology, China), Ming Wen  (Huazhong University of Science and Technology, China), Yongqiang Tian  (University of Waterloo, Canada, and The Hong Kong University of  Science and Technology, China), Bo Wu (MIT-IBM Watson AI Lab in  Cambridge, U.S.), and Shing-Chi Cheung (The Hong Kong University of  Science and Technology and Guangzhou HKUST Fok Ying Tung Research  Institute, China)	573
DeepStability: A Study of Unstable Numerical Methods and Their Solutions in Deep Learning Eliska Kloberdanz (Iowa State University, USA), Kyle Kloberdanz (Cape Privacy, USA), and Wei Le (Iowa State University, USA)	586
DeepState: Selecting Test Suites to Enhance the Robustness of Recurrent Neural Networks	598
DeepSTL - From English Requirements to Signal Temporal Logic	610
DeepTraLog: Trace-Log Combined Microservice Anomaly Detection Through Graph-Based Deep Learning	623
DeFault: Mutual Information-Based Crash Triage for Massive Crashes  Xing Zhang (National University of Defense Technology, China), Jiongyi  Chen (National University of Defense Technology, China), Chao Feng (National University of Defense Technology, China), Ruilin Li (National University of Defense Technology, China), Wenrui Diao (Shandong University, China), Kehuan Zhang (The Chinese University of Hong Kong, China), Jing Lei (National University of Defense Technology, China), and Chaojing Tang (National University of Defense Technology, China)	635
Demystifying Android Non-SDK APIs: Measurement and Understanding  Shishuai Yang (Shandong University, China), Rui Li (Shandong  University, China), Jiongyi Chen (National University of Defense  Technology, China), Wenrui Diao (Shandong University, China), and  Shanqing Guo (Shandong University, China)	647

Demystifying the Dependency Challenge in Kernel Fuzzing	659
Demystifying the Vulnerability Propagation and Its Evolution via Dependency Trees in the NPM Ecosystem	. 672
DescribeCtx: Context-Aware Description Synthesis for Sensitive Behaviors in Mobile Apps	685
Detecting False Alarms from Automatic Static Analysis Tools: How Far are We?  Hong Jin Kang (Singapore Management University, Singapore), Khai Loong  Aw (Singapore Management University, Singapore), and David Lo (Singapore Management University, Singapore)	. 698
"Did You Miss My Comment or What?" Understanding Toxicity in Open Source Discussions	.710
Difuzer: Uncovering Suspicious Hidden Sensitive Operations in Android Apps  Jordan Samhi (University of Luxembourg, Luxembourg), Li Li (Monash  University, Australia), Tegawendé F. Bissyandé (University of  Luxembourg, Luxembourg), and Jacques Klein (University of Luxembourg,  Luxembourg)	.723
Discovering Repetitive Code Changes in Python ML Systems  Malinda Dilhara (University of Colorado Boulder, USA), Ameya Ketkar (Uber Technologies Inc., USA), Nikhith Sannidhi (University of Colorado Boulder, USA), and Danny Dig (University of Colorado Boulder, USA)	736
Diversity-Driven Automated Formal Verification	749
Domain-Specific Analysis of Mobile App Reviews Using Keyword-Assisted Topic Models	762
DrAsync: Identifying and Visualizing Anti-Patterns in Asynchronous JavaScript	774

Dynamic Update for Synthesized GR(1) Controllers	786
EAGLE: Creating Equivalent Graphs to Test Deep Learning Libraries	798
Efficient Online Testing for DNN-Enabled Systems Using Surrogate-Assisted and Many-Objective Optimization	811
Eflect: Porting Energy-Aware Applications to Shared Environments	<b>82</b> 3
EREBA: Black-box Energy Testing of Adaptive Neural Networks  Mirazul Haque (The University of Texas at Dallas), Yaswanth Yadlapalli  (The University of Texas at Dallas), Wei Yang (The University of Texas at Dallas), and Cong Liu (The University of Texas at Dallas)	835
Evaluating and Improving Neural Program-Smoothing-Based Fuzzing  Mingyuan Wu (Southern University of Science and Technology and the University of Hong Kong, China), Ling Jiang (Southern University of Science and Technology, China), Jiahong Xiang (Southern University of Science and Technology, China), Yuqun Zhang (Southern University of Science and Technology, China), Guowei Yang (The University of Queensland, Australia), Huixin Ma (Tencent Security Keen Lab, China), Sen Nie (Tencent Security Keen Lab, China), Shi Wu (Tencent Security Keen Lab, China), Heming Cui (The University of Hong Kong, China), and Lingming Zhang (University of Illinois, USA)	847
ExAIS: Executable AI Semantics	859
Explanation-Guided Fairness Testing Through Genetic Algorithm  Ming Fan (Xi'an Jiaotong University, China), Wenying Wei (Xi'an  Jiaotong University, China), Wuxia Jin (Xi'an Jiaotong University,  China), Zijiang Yang (Xi'an Jiaotong University, China), and Ting Liu  (Xi'an Jiaotong University, China)	871
Exploiting Input Sanitization for Regex Denial of Service	883

FADATest: Fast and Adaptive Performance Regression Testing of Dynamic Binary Translation  Systems	896
Jin Wu (Harbin Institute of Technology, China), Jian Dong (Harbin Institute of Technology, China), Ruili Fang (University of Georgia, USA), Wen Zhang (University of Georgia, USA), Wenwen Wang (University of Georgia, USA), and Decheng Zuo (Harbin Institute of Technology, China)	
Fairness-Aware Configuration of Machine Learning Libraries	909
FairNeuron: Improving Deep Neural Network Fairness with Adversary Games on Selective Neurons	921
Fast and Precise Application Code Analysis Using a Partial Library	934
Fast Changeset-Based Bug Localization with BERT	946
Fault Localization via Efficient Probabilistic Modeling of Program Semantics	958
FIRA: Fine-Grained Graph-Based Code Change Representation for Automated Commit Message Generation	970
FlakiMe: Laboratory-Controlled Test Flakiness Impact Assessment	982
Free Lunch for Testing: Fuzzing Deep-Learning Libraries from Open Source	995

Fuzzing Class Specifications	. 1008
Garbage Collection Makes Rust Easier to Use: A Randomized Controlled Trial of the Bronze Garbage Collector	. 1021
Generating and Visualizing Trace Link Explanations	. 1033
GIFdroid: Automated Replay of Visual Bug Reports for Android Apps	. 1045
GitHub Sponsors: Exploring a New Way to Contribute to Open Source  Naomichi Shimada (Nara Institute of Science and Technology, Japan),  Tao Xiao (Nara Institute of Science and Technology, Japan), Hideaki  Hata (Shinshu University, Japan), Christoph Treude (University of  Melbourne, Australia), and Kenichi Matsumoto (Nara Institute of  Science and Technology, Japan)	. 1058
GraphFuzz: Library API Fuzzing with Lifetime-Aware Dataflow Graphs	1070
Green AI: Do Deep Learning Frameworks Have Different Costs?  Stefanos Georgiou (Queen's University), Maria Kechagia (University College London), Tushar Sharma (Dalhousie Uninversity), Fedrica Sarro (University College London), and Ying Zou (Queen's University)	. 1082
Guidelines for Assessing the Accuracy of Log Message Template Identification Techniques  Zanis Ali Khan (University of Luxembourg, Luxembourg), Donghwan Shin (University of Luxembourg, Luxembourg), Domenico Bianculli (University of Luxembourg, Luxembourg), and Lionel Briand (University of Luxembourg, Luxembourg; University of Ottawa, Canada)	1095
Hashing It Out: A Survey of Programmers' Cannabis Usage, Perception, and Motivation	. 1107
Hiding Critical Program Components via Ambiguous Translation	. 1120

History-Driven Test Program Synthesis for JVM Testing
If a Human Can See It, So Should Your System: Reliability Requirements for Machine Vision  Components
Imperative Versus Declarative Collection Processing: An RCT on the Understandability of Traditional Loops Versus the Stream API in Java
Improving Fault Localization and Program Repair with Deep Semantic Features and Transferred Knowledge
Improving Machine Translation Systems via Isotopic Replacement
Inference and Test Generation Using Program Invariants in Chemical Reaction Networks
Inferring and Applying Type Changes
Jigsaw: Large Language Models Meet Program Synthesis

JuCify: A Step Towards Android Code Unification for Enhanced Static Analysis	1232
University), Kevin Allix (University of Luxembourg), Tegawendé F. Bissyandé (University of Luxembourg), and Jacques Klein (University of Luxembourg)	
Knowledge-Based Environment Dependency Inference for Python Programs  Hongjie Ye (University of Chinese Academy of Sciences, China), Wei Chen (Institute of Software, Chinese Academy of Sciences, China), Wensheng Dou (Institute of Software, Chinese Academy of Sciences, China), Guoquan Wu (Institute of Software, Chinese Academy of Sciences, China), and Jun Wei (Institute of Software, Chinese Academy of Sciences, China)	1245
Large-Scale Security Measurements on the Android Firmware Ecosystem  Qinsheng Hou (Shandong University, China; QI-ANXIN Technology Research Institute, China), Wenrui Diao (Shandong University, China), Yanhao  Wang (QI-ANXIN Technology Research Institute, China), Xiaofeng Liu (Shandong University, China), Song Liu (QI-ANXIN Technology Research Institute, China), Lingyun Ying (QI-ANXIN Technology Research Institute, China), Shanqing Guo (Shandong University, China; Quancheng Laboratory, China), Yuanzhi Li (QI-ANXIN Technology Research Institute, China), Meining Nie (QI-ANXIN Technology Research Institute, China), and Haixin Duan (Tsinghua University, China; Tsinghua University-QI-ANXIN Group JCNS, China)	1257
Learning and Programming Challenges of Rust: A Mixed-Methods Study	1269
Learning Probabilistic Models for Static Analysis Alarms	1282
Learning to Recommend Method Names with Global Context	1294
Learning to Reduce False Positives in Analytic Bug Detectors	1307
Less is More: Supporting Developers in Vulnerability Detection During Code Review	1317

Lessons from Eight Years of Operational Data from a Continuous Integration Service: An Exploratory Case Study of CircleCI	1330
Keheliya Gallaba (Centre for Software Excellence, Canada), Maxime Lamothe (Polytechnique Montreal, Canada), and Shane McIntosh (University of Waterloo, Canada)	
Linear-Time Temporal Logic Guided Greybox Fuzzing  Ruijie Meng (National University of Singapore, Singapore), Zhen Dong (Fudan University, China; University of British Columbia, Canada), Jialin Li (National University of Singapore, Singapore), Ivan Beschastnikh (University of British Columbia, Canada), and Abhik Roychoudhury (National University of Singapore, Singapore)	1343
Log-Based Anomaly Detection with Deep Learning: How Far are We?	1356
Manas: Mining Software Repositories to Assist AutoML  Giang Nguyen (Iowa State University, USA), Md Johirul Islam (Iowa State University, USA), Rangeet Pan (Iowa State University, USA), and Hridesh Rajan (Iowa State University, USA)	1368
Modeling Review History for Reviewer Recommendation: A Hypergraph Approach	1381
ModX: Binary Level Partially Imported Third-Party Library Detection via Program  Modularization and Semantic Matching	1393
MOREST: Model-Based RESTful API Testing with Execution Feedback  Yi Liu (Nanyang Technological University, Singapore), Yuekang Li (Nanyang Technological University, Singapore), Gelei Deng (Nanyang Technological University, Singapore), Yang Liu (Nanyang Technological University, Singapore), Ruiyuan Wan (Huawei Cloud Computing Technologies Co., Ltd, China), Runchao Wu (Huawei Cloud Computing Technologies Co., Ltd, China), Dandan Ji (Huawei Technologies Co., Ltd, China), Shiheng Xu (Huawei Cloud Computing Technologies Co., Ltd, China), and Minli Bao (Huawei Cloud Computing Technologies Co., Ltd, China)	1406
Muffin: Testing Deep Learning Libraries via Neural Architecture Fuzzing	1418

Multi-intention-Aware Configuration Selection for Performance Tuning	31
Multilingual Training for Software Engineering	43
MVD: Memory-Related Vulnerability Detection Based on Flow-Sensitive Graph Neural Networks14 Sicong Cao (Yangzhou University, China), Xiaobing Sun (Yangzhou University, China), Lili Bo (Yangzhou University, China), Rongxin Wu (Xiamen University, China), Bin Li (Yangzhou University, China), and Chuanqi Tao (Nanjing University of Aeronautics and Astronautics, China)	56
Nalin: Learning from Runtime Behavior to Find Name-Value Inconsistencies in Jupyter Notebooks	69
Natural Attack for Pre-Trained Models of Code	82
Nessie: Automatically Testing JavaScript APIs with Asynchronous Callbacks	94
Neural Program Repair with Execution-Based Backpropagation	06
NeuronFair: Interpretable White-Box Fairness Testing through Biased Neuron Identification 15  Haibin Zheng (Zhejiang University of Technology), Zhiqing Chen (Zhejiang University), Tianyu Du (Zhejiang University), Xuhong Zhang (Zhejiang University), Yao Cheng (Huawei International Pte. Ltd.), Shouling Ji (Zhejiang University), Jingyi Wang (Zhejiang University), Yue Yu (National University of Defense Technology), and Jinyin Chen (Zhejiang University of Technology)	19
NPEX: Repairing Java Null Pointer Exceptions Without Tests	32

Nufix: Escape From NuGet Dependency Maze  Zhenming Li (Northeastern University, China), Ying Wang (Northeastern  University, China), Zeqi Lin (Microsoft Research Asia, China),  Shing-Chi Cheung (The Hong Kong University of Science and Technology,  China), and Jian-Guang Lou (Microsoft Research Asia, China)	1545
OJXPerf: Featherlight Object Replica Detection for Java Programs	1558
On Debugging the Performance of Configurable Software Systems: Developer Needs and Tailored Tool Support	1571
On the Benefits and Limits of Incremental Build of Software Configurations: An Exploratory Study	1584
On the Evaluation of Neural Code Summarization	1597
Ensheng Shi (Xi'an Jiaotong University), Yanlin Wang (Microsoft Research), Lun Du (Microsoft Research), Junjie Chen (Tianjin University), Shi Han (Microsoft Research), Hongyu Zhang (The University of Newcastle), Dongmei Zhang (Microsoft Research), and Hongbin Sun (Xian Jiaotong University)	
Research), Lun Du (Microsoft Research), Junjie Chen (Tianjin University), Shi Han (Microsoft Research), Hongyu Zhang (The University of Newcastle), Dongmei Zhang (Microsoft Research), and	
Research), Lun Du (Microsoft Research), Junjie Chen (Tianjin University), Shi Han (Microsoft Research), Hongyu Zhang (The University of Newcastle), Dongmei Zhang (Microsoft Research), and Hongbin Sun (Xian Jiaotong University)  On the Importance of Building High-Quality Training Datasets for Neural Code Search Zhensu Sun (Monash University, Australia), Li Li (Tongji University, China), Yan Liu (Tongji University, China), Xiaoning Du (Monash	1609
Research), Lun Du (Microsoft Research), Junjie Chen (Tianjin University), Shi Han (Microsoft Research), Hongyu Zhang (The University of Newcastle), Dongmei Zhang (Microsoft Research), and Hongbin Sun (Xian Jiaotong University)  On the Importance of Building High-Quality Training Datasets for Neural Code Search Zhensu Sun (Monash University, Australia), Li Li (Tongji University, China), Yan Liu (Tongji University, China), Xiaoning Du (Monash University, Australia), and Li Li (Monash University, Australia)  On the Reliability of Coverage-Based Fuzzer Benchmarking Marcel Böhme (MPI-SP, Germany; Monash University, Australia), László	1609 1621

Path Transitions Tell More: Optimizing Fuzzing Schedules via Runtime Program States
PerfSig: Extracting Performance Bug Signatures via Multi-Modality Causal Analysis
Practical Automated Detection of Malicious npm Packages
Practitioners' Expectations on Automated Code Comment Generation
PReach: A Heuristic for Probabilistic Reachability to Identify Hard to Reach Statements
Precise Divide-By-Zero Detection with Affirmative Evidence
Preempting Flaky Tests via Non-Idempotent-Outcome Tests
Prioritizing Mutants to Guide Mutation Testing
ProMal: Precise Window Transition Graphs for Android via Synergy of Program Analysis and Machine Learning

PropR: Property-Based Automatic Program Repair	1768
PUS: A Fast and Highly Efficient Solver for Inclusion-Based Pointer Analysis	1781
Push-Button Synthesis of Watch Companions for Android Apps	1793
Quantifying Permissiveness of Access Control Policies  William Eiers (University of California Santa Barbara, USA), Ganesh Sankaran (University of California Santa Barbara, USA), Albert Li (University of California Santa Barbara, USA), Emily O'Mahony (University of California Santa Barbara, USA), Benjamin Prince (University of California Santa Barbara, USA), and Tevfik Bultan (University of California Santa Barbara, USA)	1805
R2Z2: Detecting Rendering Regressions in Web Browsers through Differential Fuzz Testing Suhwan Song (Seoul National University, South Korea), Jaewon Hur (Seoul National University, South Korea), Sunwoo Kim (Seoul National University, South Korea), Philip Rogers (Google, United States), and Byoungyoung Lee (Seoul National University, South Korea)	1818
Recommending Good First Issues in GitHub OSS Projects	1830
Refty: Refinement Types for Valid Deep Learning Models  Yanjie Gao (Microsoft Research, China), Zhengxian Li (Microsoft Research, China), Haoxiang Lin (Microsoft Research, China), Hongyu Zhang (The University of Newcastle, Australia), Ming Wu (Shanghai Tree-Graph Blockchain Research Institute, China), and Mao Yang (Microsoft Research, China)	1843
ReMoS: Reducing Defect Inheritance in Transfer Learning via Relevant Model Slicing	1856
Repairing Brain-Computer Interfaces with Fault-Based Data Acquisition  Cailin Winston (University of Washington, USA), Caleb Winston  (University of Washington, USA), Chloe N Winston (University of Washington, USA), Claris Winston (University of Washington, USA),  Cleah Winston (University of Washington, USA), Rajesh P N Rao  (University of Washington, USA), and René Just (University of Washington, USA)	1869

Repairing Order-Dependent Flaky Tests via Test Generation	1881
Retrieving Data Constraint Implementations Using Fine-Grained Code Patterns  Juan Manuel Florez (The University of Texas at Dallas, USA), Jonathan  Perry (The University of Texas at Dallas, USA), Shiyi Wei (The  University of Texas at Dallas, USA), and Andrian Marcus (The  University of Texas at Dallas, USA)	1893
RoPGen: Towards Robust Code Authorship Attribution via Automatic Coding Style Transformation	1906
Zhen Li (University of Texas at San Antonio, USA; Huazhong University of Science and Technology, China), Guenevere (Qian) Chen (University of Texas at San Antonio, USA), Chen Chen (University of Central Florida, USA), Yayi Zou (Northeastern University, China), and Shouhuai Xu (University of Colorado Colorado Springs, USA)	1900
Rotten Apples Spoil the Bunch: An Anatomy of Google Play Malware	1919
SapientML: Synthesizing Machine Learning Pipelines by Learning from Human-Written Solutions	1932
Search-Based Diverse Sampling from Real-World Software Product Lines  Yi Xiang (South China University of Technology, China), Han Huang (South China University of Technology, China), Yuren Zhou (Sun Yat-Sen University, China), Sizhe Li (South China University of Technology, China), Chuan Luo (Microsoft Research, China), Qingwei Lin (Microsoft Research, China), Miqing Li (University of Birmingham, UK), and Xiaowei Yang (South China University of Technology, China)	1945
Semantic Image Fuzzing of AI Perception Systems  Trey Woodlief (University of Virginia, USA), Sebastian Elbaum (University of Virginia, USA), and Kevin Sullivan (University of Virginia, USA)	1958
ShellFusion: Answer Generation for Shell Programming Tasks via Knowledge Fusion  Neng Zhang (Sun Yat-sen University, China), Chao Liu (Chongqing  University, China), Xin Xia (Software Engineering Application  Technology Lab, China), Christoph Treude (University of Melbourne,  Australia), Ying Zou (Queen's University, Canada), David Lo (Singapore  Management University, Singapore), and Zibin Zheng (Sun Yat-sen  University, China)	1970

SnR: Constraint-Based Type Inference for Incomplete Java Code Snippets  Yiwen Dong (University of Waterloo, Canada), Tianxiao Gu (Alibaba Group, China), Yongqiang Tian (University of Waterloo, Canada), and Chengnian Sun (University of Waterloo, Canada)	1982
Social Science Theories in Software Engineering Research  Tobias Lorey (University of Innsbruck, Austria), Paul Ralph (Dalhousie  University, Canada), and Michael Felderer (University of Innsbruck,  Austria)	. 1994
SPT-Code: Sequence-to-Sequence Pre-Training for Learning Source Code Representations	2006
Static Inference Meets Deep Learning: A Hybrid Type Inference Approach for Python	2019
Static Stack-Preserving Intra-Procedural Slicing of WebAssembly Binaries	. 2031
Striking a Balance: Pruning False-Positives from Static Call Graphs  Akshay Utture (University of California, Los Angeles, USA), Shuyang  Liu (University of California, Los Angeles, USA), Christian Gram  Kalhauge (DTU, Denmark), and Jens Palsberg (University of California,  Los Angeles, USA)	. 2043
SugarC: Scalable Desugaring of Real-World Preprocessor Usage into Pure C  Zachary Patterson (The University of Texas at Dallas, USA), Zenong  Zhang (The University of Texas at Dallas, USA), Brent Pappas  (University of Central Florida, USA), Shiyi Wei (The University of  Texas at Dallas, USA), and Paul Gazzillo (University of Central  Florida, USA)	. 2056
SymTuner: Maximizing the Power of Symbolic Execution by Adaptively Tuning External Parameters  Sooyoung Cha (Sungkyunkwan University, Republic of Korea), Myungho Lee (Korea University, Republic of Korea), Seokhyun Lee (Korea University, Republic of Korea), and Hakjoo Oh (Korea University, Republic of Korea)	. 2068
Testing Time Limits in Screener Questions for Online Surveys with Programmers	. 2080

The Art and Practice of Data Science Pipelines: A Comprehensive Study of Data Science Pipelines In Theory, In-The-Small, and In-The-Large	)91
The Extent of Orphan Vulnerabilities from Code Reuse in Open Source Software	.04
"This Is Damn Slick!" Estimating the Impact of Tweets on Open Source Project Popularity and New Contributors	16
TOGA: A Neural Method for Test Oracle Generation	.30
Towards Automatically Repairing Compatibility Issues in Published Android Apps	.42
Towards Bidirectional Live Programming for Incomplete Programs	.54
Towards Boosting Patch Execution On-the-Fly	.65
Towards Language-Independent Brown Build Detection	.77
Towards Practical Robustness Analysis for DNNs Based on PAC-Model Learning	89

Towards Training Reproducible Deep Learning Models  Boyuan Chen (Centre for Software Excellence, Canada), Mingzhi Wen (Huawei Technologies, China), Yong Shi (Huawei Technologies, China), Dayi Lin (Centre for Software Excellence, Canada), Gopi Krishnan Rajbahadur (Centre for Software Excellence, Canada), and Zhen Ming (Jack) Jiang (York University, Canada)	2202
Training Data Debugging for the Fairness of Machine Learning Software  Yanhui Li (Nanjing University, China), Linghan Meng (Nanjing University, China), Lin Chen (Nanjing University, China), Li Yu (Nanjing University, China), Di Wu (Momenta, Suzhou, China), Yuming Zhou (Nanjing University, China), and Baowen Xu (Nanjing University, China)	. 2215
Trust Enhancement Issues in Program Repair	. 2228
Type4Py: Practical Deep Similarity Learning-Based Type Inference for Python	2241
Unleashing the Power of Compiler Intermediate Representation to Enhance Neural Program Embeddings	2253
Use of Test Doubles in Android Testing: An In-Depth Investigation  Mattia Fazzini (University of Minnesota, USA), Chase Choi (University of Minnesota, USA), Juan Manuel Copia (IMDEA Software Institute, Spain), Gabriel Lee (University of Minnesota, USA), Yoshiki Kakehi (Georgia Institute of Technology, USA), Alessandra Gorla (IMDEA Software Institute, Spain), and Alessandro Orso (Georgia Institute of Technology, USA)	2266
Using Deep Learning to Generate Complete Log Statements	. 2279
Using Pre-Trained Models to Boost Code Review Automation	2291

Using Reinforcement Learning for Load Testing of Video Games  Rosalia Tufano (Università della Svizzera italiana, Switzerland),  Simone Scalabrino (University of Molise, Italy), Luca Pascarella (Università della Svizzera italiana, Switzerland), Emad Aghajani (Università della Svizzera italiana, Switzerland), Rocco Oliveto (University of Molise, Italy), and Gabriele Bavota (Università della Svizzera italiana, Switzerland)	2303
Utilizing Parallelism in Smart Contracts on Decentralized Blockchains by Taming Application-Inherent Conflicts	2315
VarCLR: Variable Semantic Representation Pre-Training via Contrastive Learning	2327
Verification of ORM-Based Controllers by Summary Inference	2340
V-SZZ: Automatic Identification of Version Ranges Affected by CVE Vulnerabilities	2352
VulCNN: An Image-Inspired Scalable Vulnerability Detection System Yueming Wu (Huazhong University of Science and Technology, China), Deqing Zou (Huazhong University of Science and Technology, China), Shihan Dou (Fudan University, China), Wei Yang (University of Texas at Dallas, United States), Duo Xu (Huazhong University of Science and Technology, China), and Hai Jin (Huazhong University of Science and Technology, China)	2365
What Do They Capture? - A Structural Analysis of Pre-Trained Language Models for Source Code	2377
What Makes a Good Commit Message?  Yingchen Tian (Beijing Institute of Technology, China), Yuxia Zhang (Beijing Institute of Technology, China), Klaas-Jan Stol (University College Cork and Lero, Ireland), Lin Jiang (Beijing Institute of Technology, China), and Hui Liu (Beijing Institute of Technology, China)	2389

What Makes Effective Leadership in Agile Software Development Teams?	.402
What the Fork? Finding Hidden Code Clones in npm	415
Where is Your App Frustrating Users?	2427
WindRanger: A Directed Greybox Fuzzer Driven by Deviation Basic Blocks	2440

## **Author Index**