COVID-19's Impact on Mental Health—The Hour of Computational Aid?

WELCOME to the fourth issue of IEEE TRANSACTIONS ON COMPUTATIONAL SOCIAL SYSTEMS (TCSS) in 2022. First, we have some exciting news to share. In late June, Clarivate updated the Impact Factor of all journals which are indexed by Web of Science. According to the Journal Citation Reports, the 2021 Journal Impact Factor of IEEE TCSS was 4.727. Many thanks to all for your great effort and support.

After the usual introduction of our 25 regular articles, we would like to discuss the topic of "COVID-19's Impact on Mental Health—The Hour of Computational Aid?"

I. SCANNING THE ISSUE

1. "Three-Party Evolutionary Game Model of Stakeholders in Mobile Crowdsourcing" by *Fuxing Li, Yingjie Wang, Yang Gao, Xiangrong Tong, Nan Jiang, and Zhipeng Cai*

This article proposes a three-party evolutionary game model among task requester, platform, and crowd workers. To make the model more realistic, it takes into account the cooperation between crowd workers and the platform. The evolutionary stability approach is then examined using the replication dynamics technique. To avoid free-riding and false-reporting issues, incentive and penalty techniques are provided. Finally, simulation tests are used to verify the stability of the equilibrium point in the three-party game system, and effective strategies for motivating each participant to adopt a trustworthy strategy are presented.

2. "Robust Collaborative Filtering Recommendation With User-Item-Trust Records" by *Fan Wang, Haibin Zhu, Gautam Srivastava, Shancang Li, Mohammad R. Khosravi, and Lianyong Qi*

This work initially introduces the Trust-based Collaborative Filtering (TbCF) algorithm, which does basic rating prediction in a way similar to previous CF algorithms. The authors then present the Hybrid Collaborative Filtering Recommendation Method with User-Item-Trust Records (UIThybrid), a unique strategy for supplementing rating information that combines user trust into existing CF-based approaches in a harmonic fashion. UIThybrid uses several views to extract appropriate services and achieves a good balance between the recommendation's robustness, correctness, and variety.

3. "SOIDP: Predicting Interlayer Links in Multiplex Networks" by *Xiao Ding, Chuang Ma, Xingyi Zhang, Han-Shuang Chen, and Hai-Feng Zhang*

The authors propose a second-order iterative degree penalty (SOIDP) algorithm for predicting interlayer links in multiplex networks, in which the information of first- and second-order common matched neighbors (CMNs) is taken into account, as well as a degree penalty mechanism to give CMNs with fewer connections more weight. They show that the interlayer linkages may be directly anticipated by calculating the matching degree matrix without iteration, which solves the problem of cumulative error in the iterative procedure.

4. "Compatible Influence Maximization in Online Social Networks" by *Lei Yu, Guohui Li, and Ling Yuan*

The authors investigate a unique compatible impact maximization issue for two goods, which entails more difficult product adoption decisions by consumers in a variety of realistic scenarios. The issue is NP-hard, and the objective function's monotonicity and submodularity have vanished. To tackle the problem successfully, they suggest a modified greedy algorithm. They also present a fast greedy approach that includes multiple successful optimization strategies without compromising accuracy and design an efficient heuristic algorithm to estimate the influence spread calculation due to its low computing efficiency in seed selection.

5. "Research and Implementation of Chinese Couplet Generation System With Attention Based Transformer Mechanism" by *Yufeng Wang, Jiang Zhang, Bo Zhang, and Qun Jin*

The transformer technique is used in this article to create meaningful Chinese couplets. First, because the words in the antecedent and subsequent clauses of a Chinese couplet always have the same part-of-speech (pos, i.e., word class), pos information is purposely supplied to the Transformer to increase the correctness of the imagined couplet. Second, a particular unregistered/low-frequency word processing mechanism is devised and integrated with the Transformer model to cope with the huge number of unregistered and low-frequency words in Chinese couplets. Third, the authors include polish mechanisms (PMs) into the transformer model to increase couplet coherence even further.

6. "Connections Between Relational Event Model and Inverse Reinforcement Learning for Characterizing Group Interaction Sequences" by *Congyu Wu*

In this article, the author explores the previously unidentified connections between the relational event model (REM) from the field of network science and inverse reinforcement learning (IRL) from the field of machine learning. The author begins by examining the mathematical components of both REM and IRL and find straightforward analogies between the two methods and the unique characteristics of the IRL approach. The author demonstrates the special utility of IRL

Digital Object Identifier 10.1109/TCSS.2022.3191821

in characterizing group social interactions with two empirical experiments.

7. "Authorship Attribution of Microtext Using Capsule Networks" by *Chanchal Suman, Ayush Raj, Sriparna Saha, and Pushpak Bhattacharyya*

For the authorship attribution (AA) challenge, this article provides a capsule-based convolutional neural network (CNN) model over character n-grams. For this purpose, a capsule with kervolutional neural networks (KNNs) was also used. This page also includes many studies of its established system, which helps to improve its interpretability. The essential text fragments for the prediction task are shown as heat maps for different models. The results of the experimental assessment reveal that capsule-based CNNs and KNNs outperform earlier techniques.

8. "Time-Series Snapshot Network for Partner Recommendation: A Case Study on OSS" by *Yunyi Xie, Jinyin Chen, Jian Zhang, Xincheng Shu, and Qi Xuan*

This article introduces a time-series snapshot network (TSSN), which is a mixture network to model the interactions among users and developers. Then, the authors perform a temporal biased walk (TBW) to automatically obtain the time information and structure information of the mail network based on the established TSSN. The experiments on ten Apache data sets prove that the proposed TBW significantly outperforms a number of advanced random walk-based embedding methods, leading to the state-of-the-art recommendation performance.

9. "A Kind of Change Management Method for Global Value Chain Optimization and Its Case Study" by *Guangyu Xiong, Huaiyu Wu, Petri Helo, Xiuqin Shang, Gang Xiong, Rui Qin, and FeiYue Wang*

This article introduces one kind of change management method to support a process change through a global value chain (GVC) in multiple organizations, and the method is used in a case study to achieve a successful change. The achieved result shows that the proposed change management method not only helped the case GVC to implement the change successfully but also can help the relevant multiple organizations to improve the GVC performance and add value by optimizing their problem process.

10. "Skyline (λ, k)-Cliques Identification From Fuzzy Attributed Social Networks" by *Fei Hao, Jie Gao, Jianrui Chen, Aziz Nasridinov, and Geyong Min*

This article develops a formal concept analysis (FCA)-based skyline (λ,k)-cliques identification technique and formulates a unique model of the skyline (λ, k)-cliques across a fuzzy attributed social network. Specifically, it can be used as a quality control metric for determining the cohesive grouping stability. The extensive experimental results show that proposed skyline (λ, k)-clique model can be widely used in various graph-based computational social systems, such as optimal team formation in crowdsourcing, and group recommendation in social networks.

11. "Optimal Cyber-Insurance Contract Design for Dynamic Risk Management and Mitigation" by *Rui Zhang and Quanyan Zhu*

This article presents a dynamic moral-hazard type of the principal–agent model incorporated with Markov decision processes to capture the interactions between the users and the insurers, which are used to capture the dynamics and correlations of the cyber risks as well as the user's decisions on the protections. Numerical experiments are provided to verify conclusions and further extend to cases of a four-state three-action user under linear coverage insurance and threshold coverage insurance.

12. "Analysis of Public Sentiment on COVID-19 Vaccination Using Twitter" by *Gutti Gowri Jayasurya, Sanjay Kumar, Binod Kumar Singh, and Vinay Kumar*

In this work, the sentiment analysis of tweets is performed using 14 different machine learning classifiers and natural language processing (NLP). Lexicon-based TextBlob and Vader are used for annotating the data in order to perform sentiment analysis on the subject of COVID-19 vaccination, perform temporal and spatial analyses of the textual data, and find the most frequently discussed topics that may help organizations bring awareness to those topics. A natural language toolkit is used for preprocessing the textual data. The experimental results reveal the dates and times in which most positive, negative, and neutral tweets are posted.

13. "Cooperative and Parallel Fog Discovery and Pareto Optimal Fog Commerce Bargaining" by *Kwang Mong Sim*

This article devises the KM-gossip algorithm for bolstering fog discovery and a bargaining mechanism for pricing fog resources. The KM-gossip algorithm is a generalization of the gossip algorithm. It uses K broker agents (BAs) to cooperatively "gossip" requests among themselves, and in parallel, each BA relays the requests to M fog nodes. The empirical results show that it significantly outperforms the existing gossip and flooding algorithms.

14. "Modeling the Impact of Social Distancing on the COVID-19 Pandemic in a Low Transmission Setting" by *Junxiao Xue, Mingchuang Zhang, and Mingliang Xu*

This article proposes a new method for deterministic modeling of the effects of social distancing on the COVID-19 pandemic in a low transmission setting. Model dynamic satisfies an integro-differential equation expressed by a single predictive variable. After the dynamic variables are calculated, the states of the medicament in the process can be explored. Besides, it adds an important parameter to the model to measure the impact of social distancing on epidemic transmission. The results showed that 2 m is a safe social distancing in the COVID-19 pandemic in a low transmission setting.

15. "Influence Spread in Location-Based Social Network: An Efficient Algorithm of Epidemic Controlling" by *Xiaopeng Yao, Xiaowei Han, Yue Gu, Chonglin Gu, and Hejiao Huang*

In this article, a piecewise function considering distance and time is proposed to measure the infection probability of each user. Then, an algorithm called location-infected-greedy is proposed to solve the minimized epidemic infection problem by finding seed nodes considering infection probability, check-in time, location information and user influence. Finally, a large number of comparative experiments on real location-based social networks show that the proposed algorithm is effective.

16. "A Novel Approach to Select High-Reward Data Items in Big Data Stream Based on Multiarmed Bandit" by *Shun Wang and Guosun Zeng*

This article puts forward a selection strategy based on multiarmed bandits. According to the different characteristics of data items, the data items arriving online are cached in different buffers. The authors designed three selection strategies: the improved ϵ-greedy, the improved upper confidence bound, and a data item selection policy named dynamic high-reward incentive with active, dynamic, and incentive rewards. The experimental results show that this method is effective and its performance is better than the traditional method.

17. "Real-Time Text Classification of User-Generated Content on Social Media: Systematic Review" by *David Rogers, Alun Preece, Martin Innes, and Irena Spasić*

This article illustrates a systematic review to determine the current state of the art in the real-time classification of user-generated content from social media. It compares a total of 25 studies published between 2014 and 2018 covering 15 types of classification algorithms. In a word, there are consistent methods for standardizing social media data for text mining, and the traditional text mining technology is suitable for the real-time analysis task of social media.

18. "A Robust Minimum-Cost Consensus Model With Uncertain Aggregation Weights Based on Data-Driven Method" by *Yefan Han, Ying Ji, and Shaojian Qu*

In this article, a data-driven robust optimization method (RO) is used to deal with the uncertain weights of aggregation operators in group decision making (GDM). Two flexible uncertainty sets are established to limit the fluctuation of uncertainty and enhance the robustness of the model. The new model can effectively deal with the deviation, improve the quality of the aggregation operator, and prove the applicability of the model.

19. "Modeling and Simulating Adaptation Strategies Against Sea-Level Rise Using Multiagent Deep Reinforcement Learning" by *Salman Sadiq Shuvo, Yasin Yilmaz, Alan Bush, and Mark Hafen*

This article presents an SLR socioeconomic system. The system can be modeled as a Markov decision process (MDP) and simulated using multiagent reinforcement learning (RL). The proposed multiagent RL framework provides a general scenario planning tool to investigate the cost–benefit analysis of natural events and agents' investments. The framework also shows how much the total cost due to SLR can be reduced over time by optimizing the adaptation strategies.

20. "Multilabel Emotion Tagging for Domain-Specific Texts" by *Samuel W. K. Chan*

This article illustrates a novel approach to bootstrap a general seed emotion lexicon with words found in a domain-specific corpus. The approach divulges the contextual similarity between two words in the corpus via lexical-, dictionary-, and topic-based features, thus revealing the emotion labels of domain-specific words. The proposed novel approach provides better modeling of compositional emotions by considering the emotion-bearing words, shifters, intensifiers, and overall sentence structure.

21. "Density-Peak-Based Overlapping Community Detection Algorithm" by *Liping Sun, Tao Ye, Jian Sun, Xiaoyu Duan, and Yonglong Luo*

This article proposes an overlapping community detection algorithm that selects community centers adaptively based on density peaks. The density-peak-based overlapping community detection (DPOCD) algorithm defines point link strength and edge link strength to construct a distance matrix. The feasibility of this algorithm is evaluated by comparing it with other algorithms on the synthetic network and real complex network datasets. The results show that the method has good performance and robustness in large-scale complex networks.

22. "Computational Experiments for Complex Social Systems—Part II: The Evaluation of Computational Models" by *Min Lu, Shizhan Chen, Xiao Xue, Xiao Wang, Yufang Zhang, Yifang Zhang, and Fei-Yue Wang*

The authors take epidemic models as the research object and propose a capability maturity evaluation framework for computational models of artificial society. Specific analyses and evaluations are conducted for several representative COVID-19 models to verify the validity of this evaluation framework. The results of the case study show that the proposed evaluation framework can help decision makers identify more mature and referential models, and point out the directions where modelers can improve their models.

23. "Exploiting Long- and Short-Term Preferences for Deep Context-Aware Recommendations" by *Tipajin Thaipisutikul, Timothy K. Shih, Avirmed Enkhbat, and Wisnu Aditya*

Recurrent neural networks (RNNs) and item-based collaborative filtering (CF) models fail to different contexts that could differently influence current users' decision-making. This article exploits long and short-term preferences for deep context-aware recommendations (LSCAR) to enhance the next item recommendation's performance by introducing three novel components. The extensive experiments and results for two public datasets demonstrate that the proposed LSCAR outperforms the state-of-the-art models in almost all metrics and could provide interpretable recommendation results.

24. "Vectorial-Opinion Dynamics With Familiarity Neighborhoods in Virtual Social Groups" by *Narayani Vedam and Debasish Ghose*

This work simulates the interaction among agents on social networks and studies their impact on the evolution of agents' opinions. The article also designed an interpersonal influence score to quantify the strength of the influence and the probability of acquisition, retention, or loss of a tie. This characterization of agents' behavior and their interpersonal relationships differs from traditional bounded-confidence models based on the agreement in opinions alone. Through validation of their initial views, group composition, network structures, and network evolution rates by simulations, research results are given.

25. "SDH: Secure Data Hiding in Fused Medical Image for Smart Healthcare" by *Ashima Anand and Amit Kumar Singh*

This article introduces a new data hiding method based on image fusion for intelligent medical treatment. First, to obtain the fused coverage image, this article uses multimodal image fusion based on nonsubsampled contourlet transform, so as

to improve the accuracy of clinical diagnosis. Furthermore, the proposed method uses a magic cube algorithm for higher payload and encryption for additional authentication. The proposed technique is extensively tested, and promising results were obtained when compared with similar techniques.

II. COVID-19's Impact on Mental Health—The Hour of Computational Aid?

Covid-19-related mental health issues are a major challenge accompanying the immediate infection-based problems. Prevalence was observed to be particularly high for children and young adults, including anxious and depressive symptoms. And those already burdened by neurodiversities and physical challenges were facing a higher *a-priori* probability to be targeted [1]. Here, we reason that given additional partial social distancing and other safety measures as well as over-burdened practitioners this calls for improved computational aid such as intelligent diagnosis and monitoring as well as therapy. In the following, we first sketch the demand and then how we could best respond in terms of intelligent digital solutions.

A. COVID-19's Impact on Mental Health

Prevalence rates of mental illnesses such as anxiety and depression have been known to rise for years [2]. Rates of major depressive episode increased by 52% between 2005–2017 (from 8.7% to 13.2%) among adolescents aged 12–17 and 63% between 2009–2017 (from 8.1% to 13.2%) among young adults aged 18–25 [3]. Of these, however, only 18.9% search professional help [4]. Mental illnesses represent a considerable individual, societal, and economic burden—especially in the case where the course is chronic and recurrent [5]. Since the onset of the COVID-19 pandemic, the numbers have risen even further with an increase of 27.6% [6].

Although the whole general population is affected, research indicates particularly elevated symptoms of depression and anxiety for vulnerable groups as in mothers [7], single parents, children, and adolescents [8], and families with a low socioeconomic status, hence, groups that were socially disadvantaged even before the COVID-19 Pandemic.

One of many explanations for the increase in mental health problems is the threat of infection with the corona virus. However, this threat is accompanied by other global threats, such as climate change or armed conflicts, which cannot be reduced to a dysfunctional very individual way of interpreting a specific situation, but represent realistic dangers to a certain extent or at least societal changes. These times of rapid change may be one reason why feelings of insecurity, and thus the development of mental disorders, are on the rise. However, even before the COVID-19 pandemic, the resources of the healthcare systems were insufficient, indicated by long waiting lists for psychotherapy treatment [9], limited local accessibility [10], and insufficient endorsement by clinicians [11], despite numerous individual barriers to mental health treatment seeking such as shame, low perceived need [12], and pessimistic treatment expectations [13]. The disruptions to mental, neurological, and substance use services in over 33% of responding World Health Organization (WHO) Member States undoubtedly aggravated the situation, but were also leading to the development of new services and integration of mental health and psychosocial support [6].

All of this seems to lead inevitably to the conclusion that the hour of digital supply has come. Digitally delivered mental health interventions (as internet- and mobile-based psychotherapy—potentially AI-mediated or supported, agents, bots, online training, and mobile assessment) have the great potential to scale mental health resources for diagnostics, early detection, prevention, treatment, and after-care with low cost, independent of an individual's location and with a low threshold [14]. The anonymity that is often given in such tools may enable more reluctant individuals to seek help, as there is less of a barrier of shame that tends to be present in traditional face-to-face care [15]. In addition, opening up to a 'neutral' AI may be less biased.

Furthermore, professional support may be provided in more rural areas apart from health infrastructures and other hard-to-reach groups with language barriers (e.g., refugees). These advantages are reflected in the explosion of development of mobile health apps, with an estimation of 1.7 billion people who downloaded mobile health apps by the U.S. Food and Drug Administration in 2018 [16] and an increase of nearly 200% from summer 2019 to summer 2020 [17]. In many countries, the rise of health apps has been recognised, identified as chance to increase the health support, and approaches to integrate computational aid have been carried out. However, the plethora of mobile technology-based innovations is confusing, and those seeking help often cannot distinguish between an evidence-based [18], trustworthy offering, preferring to rely on app store stars as a basis for evaluation [19]. Hence, numerous app evaluation frameworks have been developed [20] as well as laws to increase the proof of efficacy and to prescribe an app (e.g., German Ministry of Health, 2019) alongside other attempts to guide politicians, health professionals, and users. So far, evidence is poor, and methodological standards that are defined in such approaches are either low, heterogeneous, and hard to define and capture in this dynamic field. Most mental health apps were shown to perform badly regarding data and transparency security: e.g., in a study on 116 mobile phone health apps, only 49% included a privacy policy while not being sufficiently transparent with data security information [21]. In another meta-analysis, methodological quality and attrition rates of included studies were labelled as "suboptimal" [22]). In addition, acceptance rates of digitally delivered or supported treatment was low by therapists themselves [23].

B. Computational Aid: Intelligent and Trustworthy

By now, it has been shown that depression can—to a certain extent—be monitored automatically by an AI from multiple data sources such as text [24], audio, video, and physiological data [25] as well as movement data, communication data, and many other data types from sensors on smart devices [26] or via the "Internet of Things" data [27]. It has also been demonstrated in fully comparable competition conditions that this holds even if an AI itself is interviewing a user, e.g., by a virtual smart agent [28]. Likewise, already today, depression can be automatically monitored to some degree providing feedback to users or care-takers, and the first steps into automatic

therapy have been made. However, from the above, we distil a number of pressing requirements for such AI-empowered digital solutions for combating the global rise of mental health crisis (see also [29]).

Most obviously, such computational aid has to be providing reliable and robust outputs. This has been the major effort up to this point in the research landscape. However, the evidence base of digital mental health interventions is dissatisfactory and predictions about COVID-19 development or other threats for mental health at large remain unpredictable. Hence, it is now time to create long-term solutions for establishing evidence-based digital mental health with high standards. This could ideally include some type of yet-to-be-developed AI self-assessment at scale of such computational aids to assure quality of service at run-time. It could even include AI-self-monitoring in randomized controlled trials as long as ethics are fully met.

Beyond the basic demand of delivering useful outputs, however, as in most today's AI use-cases, a number of further requirements arise. Given the vulnerable character of the user population and the sensitive nature of the data as well as the potentially severe implications of AI errors, trustworthiness seems top on the list. Such includes a number of factors, as will be touched upon next.

Clearly, full data protection—including against adversarial attacks and including in data donating settings such as federated learning—is non negligible at all times. Furthermore, transparency issues including an AI's explainability to all types of users including practitioners need to be solved. Explanations given by an AI could thereby exploit different modalities including sonficiation, verbalisation, and visualization explaining decision making, recommendations given, and their cause as well as potentially similar cases in the AI's learning database. Furthermore, such explanations require usability testing to assure they can actually be understood by different levels from laymen to experts. In addition, fairness across all user groups including their sex, age, or cultural heritage must be assured.

Next, lack of adherence [30] is one of the major challenges in many intelligent health solutions rendering usability for all target groups as well as health professionals a further crucial factor. One-size-fits-all was never applicable in psychotherapy in general and neither is true for the numerous and heterogeneous technology-based tools. Therefore, personalised interface and sensing solutions alongside high quality, large-scale randomised controlled trials following a personalised approach that are agile and flexible enough to keep up the technical development and to make digital mental health interventions impactful are hence needed.

Trustworthy, useful, and personalised computational mental health aid will, however, also need to be future-proof. If new crises arise, quick reaction time may be everything. From an AI perspective, this demands in particular for the ability to learn with a drifting target—potentially largely autonomous such as by curious, self-supervised, and reinforced approaches. If new mutations of mental health issues or changing benefiting factors appear, also being able to learn from the first few evidences will become game-changing. In this respect, zero- and few-shot as well as general transfer- and life-long-learning approaches without catastrophic forgetting can come in handy. In addition, forecasting of such factors [31] could lead to augmenting the training database in advance, e.g., by generative adversarial or variational autoencoding approaches and combinations thereof.

Finally, the more efficient solutions can be made in terms of computational requirement and memory print, the better they can usually be run at low cost—benefiting the potential spread for all, implementation fully on-device—benefiting data-protection if no server communication is needed, and potential usage at scale allowing for rapid insights into global mental health development. For example, deep learning as a currently predominating AI solution in this field, has seen a plethora of suited approaches reaching from pruning, quantifying, and squeezing networks to teacher–student and lottery ticket architectures that often allow for massive reduction in required resources.

C. Conclusion

Despite the great catalyst for implementation due to the COVID-19 pandemic, however, the field appears to be declining during periods of "low-incidence" due to the long time of social deprivation. It is therefore necessary to assess what remains of these achievements in the longer term and what was merely a necessary overcoming. Further, one needs to assess which achievements in computational aid will remain or even be expanded in the long run and what was merely a necessary overcoming if people can meet in person again.

There are approaches towards consensus for higher standards for smartphones apps and digital mental health [20] and assistance for health professionals and users seeking support.

In addition, the research fields must be expanded, adherence and uptake improved, cost–benefit analysis conducted and implementation of effective interventions into the routine care facilitated.

At all times, the focus among all technical innovations should never be neglected: empowering an individual that is facing a specific burden to be part of a society. Health is "a state of physical, mental, and social well-being" enabling and individual to work, have relationships, and express oneself in a society [32]. Well-executed, digital interventions and computational aid have the potential of being a helping hand.

BJÖRN W. SCHULLER
GLAM—Group on Language, Audio, & Music
Department of Computing
Imperial College London
London SW7 2AZ, U.K.
e-mail: schuller@ieee.org

JOHANNA LÖCHNER
Department of Child and Adolescent Psychiatry
Eberhard Karls University of Tübingen
72076 Tübingen, Germany
e-mail: johanna.loechner@med.uni-tuebingen.de

KUN QIAN
School of Medical Technology
Beijing Institute of Technology
Beijing 100081, China
e-mail: qian@bit.edu.cn

BIN HU, *Editor-in-Chief*
School of Medical Technology
Beijing Institute of Technology
Beijing 100081, China
e-mail: tcss.ieee@gmail.com

REFERENCES

[1] H. Samji *et al.*, "Review: Mental health impacts of the COVID-19 pandemic on children and youth—A systematic review," *Child Adolescent Mental Health*, vol. 27, no. 2, pp. 173–189, May 2022.
[2] R. C. Kessler, P. Berglund, O. Demler, R. Jin, K. R. Merikangas, and E. E. Walters, "Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the national comorbidity survey replication," *Arch. Gen. Psychiatry*, vol. 62, no. 6, pp. 593–602, Jun. 2005.
[3] M. J. Twenge, A. B. Cooper, E. T. Joiner, E. M. Duffy, and G. S. Binau, "Age, period, and cohort trends in mood disorder indicators and suicide-related outcomes in a nationally representative dataset, 2005–2017," *J. Abnormal Psychol.*, vol. 128, no. 3, pp. 185–199, 2019.
[4] S. Schmidt and M. Döbele, "Psychische Erkrankungen," in *Demenzbegleiter*. Berlin, Germany: Springer-Verlag, 2019, pp. 19–29.
[5] E. R. Walker, E. R. McGee, and G. B. Druss, "Mortality in mental disorders and global disease burden implications a systematic review and meta-analysis," *JAMA Psychiatry*, vol. 72, no. 4, pp. 334–341, 2015.
[6] World Health Organization, "Mental Health and COVID-19 : Early evidence of the pandemic's impact: Scientific brief," *COVID-19: Scientific Brief*, vol. 2, pp. 1–11, Mar. 2022.
[7] N. Racine *et al.*, "When the bough breaks: A systematic review and meta-analysis of mental health symptoms in mothers of young children during the COVID-19 pandemic," *Infant Mental Health J.*, vol. 43, no. 1, pp. 36–54, Jan. 2022.
[8] N. Wright, J. Hill, H. Sharp, and A. Pickles, "Interplay between long-term vulnerability and new risk: Young adolescent and maternal mental health immediately before and during the COVID-19 pandemic," *JCPP Adv.*, vol. 1, no. 1, Apr. 2021, Art. no. e12008.
[9] C. E. Adair *et al.*, "Continuity of care and health outcomes among persons with severe mental illness," *Psychiatric Services*, vol. 56, no. 9, pp. 1061–1069, Sep. 2005.
[10] H. Schulz, D. Barghaan, T. Harfst, and U. Koch, "Psychotherapeutische versorgung—Themenheft," Robert Koch-Institut, Berlin, Germany, Tech. Rep. 41, 2008.
[11] M. J. Ehrenreich, C. T. Robinson, D. B. Glovinsky, L. B. Dixon, D. R. Medoff, and S. S. Himelhoch, "Medical inpatients' adherence to outpatient psychiatric aftercare: A prospective study of patients evaluated by an inpatient consultation liaison psychiatry service," *Int. J. Psychiatry Med.*, vol. 44, no. 1, pp. 1–15, Jul. 2012.
[12] J. Schulte, C. Schulz, S. Wilhelm, and U. Buhlmann, "Treatment utilization and treatment barriers in individuals with body dysmorphic disorder," *BMC Psychiatry*, vol. 20, no. 1, pp. 1–11, Dec. 2020.
[13] M. Sibold, O. Mittag, B. Kulick, E. Müller, U. Opitz, and W. H. Jäckel, "Prädiktoren der teilnahme an einer nachsorge nach ambulanter rehabilitation bei erwerbstätigen rehabilitanden mit chronischen rückenschmerzen [1]," *Rehabilitation*, vol. 50, no. 6, pp. 363–371, 2011.
[14] S. Paganini, W. Teigelkötter, C. Buntrock, and H. Baumeister, "Economic evaluations of internet- and mobile-based interventions for the treatment and prevention of depression: A systematic review," *J. Affect. Disorders*, vol. 225, pp. 733–755, Jan. 2018.
[15] D. C. Mohr *et al.*, "Barriers to psychotherapy among depressed and nondepressed primary care patients," *Ann. Behav. Med.*, vol. 32, no. 3, pp. 254–258, Dec. 2006.
[16] *Mobile Medical Applications*, U.S. Food Administration and Drug, Silver Spring, MA, USA, 2015.
[17] *Market Facts and Figures*, Organisation for the Review of Care and Health Applications, Daresbury, U.K., 2021.
[18] M. R. Moshi, R. Tooher, and T. Merlin, "Suitability of current evaluation frameworks for use in the health technology assessment of mobile medical applications: A systematic review," *Int. J. Technol. Assessment Health Care*, vol. 34, no. 5, pp. 464–475, 2018.
[19] P. Henson, G. David, K. Albright, and J. Torous, "Deriving a practical framework for the evaluation of health apps," *Lancet Digit. Health*, vol. 1, no. 2, pp. e52–e54, Jun. 2019.
[20] J Torous, G Andersson, A Bertagnoli, and, "Towards a consensus around standards for smartphone apps and digital mental health," *World Psychiatry*, vol. 18, no. 1, pp. 1–2, Feb. 2019.
[21] K. O'Loughlin, M. Neary, E. C. Adkins, and S. M. Schueller, "Reviewing the data security and privacy policies of mobile apps for depression," *Internet Intervent.*, vol. 15, pp. 110–115, Mar. 2019.
[22] S. Hennemann, S. Farnsteiner, and L. Sander, "Internet- and mobile-based aftercare and relapse prevention in mental disorders: A systematic review and recommendations for future research," *Internet Intervent.*, vol. 14, pp. 1–17, Dec. 2018.
[23] N. Topooco *et al.*, "Attitudes towards digital treatment for depression: A European stakeholder survey. *Internet Intervent.*, vol. 8, pp. 1–9, Jun. 2017.
[24] E.-M. Rathner *et al.*, "How did you like 2017? Detection of language markers of depression and narcissism in personal narratives," in *Proc. Interspeech*, Hyderabad, India, Sep. 2018, pp. 3388–3392.
[25] F. Ringeval, B. Schuller, M. Valstar, J. Gratch, R. Cowie, and M. Pantic, "Summary for AVEC 2017: Real-life depression and affect challenge and workshop," in *Proc. 25th ACM Int. Conf. Multimedia*, Mountain View, CA, USA, Oct. 2017, pp. 1963–1964.
[26] X. He *et al.*, "Depression diagnosis and forecast based on mobile phone sensor data," in *Proc. 44th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., (EMBC)*, Glasgow, U.K., Jul. 2022, p. 4.
[27] K. Qian, Z. Zhang, Y. Yamamoto, and B. W. Schuller, "Artificial intelligence Internet of Things for the elderly: From assisted living to health-care monitoring," *IEEE Signal Process. Mag.*, vol. 38, no. 4, pp. 78–88, Jul. 2021.
[28] F. Ringeval *et al.*, "AVEC 2019 workshop and challenge: State-of-mind, detecting depression with AI, and cross-cultural affect recognition," in *Proc. 9th Int. Audio/Visual Emotion Challenge Workshop (AVEC)*, Niece, France, 2019, pp. 3–12.
[29] M. Pateraki *et al.*, "Biosensors and Internet of Things in smart healthcare applications: Challenges and opportunitie," in *Wearable and Implantable Medical Devices* (Applications in ubiquitous sensing applications for healthcare), vol. 7, N. Dey, A. Ashour, S. J. Fong, and C. Bhatt, Eds., 1st ed. Amsterdam, The Netherlands: Elsevier, 2020, ch. 2, pp. 25–53.
[30] J. Dineley *et al.*, "Remote smartphone-based speech collection: Acceptance and barriers in individuals with major depressive disorder," in *Proc. INTERSPEECH*. Brno, Czechia, ISCA, 2021, pp. 631–635.
[31] B. Schuller, Y. Eldar, M. Pantic, S. Narayanan, T. Virtanen, and J. Tao, "Intelligent signal analysis for contagious virus diseases," *IEEE J. Sel. Topics Signal Process., Special Issue Intell. Signal Anal. Contagious Virus Diseases*, vol. 16, no. 2, pp. 159–163, Feb. 2022.
[32] *Constitution of the World Health Organization—Basic Documents*, 45th ed., World Health Organization, Geneva, Switzerland, 2006.

Björn W. Schuller (Fellow, IEEE) received the Doctor and Habilitation degrees from the Technical University of Munich (TUM), Munich, Germany, in 2006 and 2012, respectively.

He is currently a Professor of artificial intelligence and the Head of Group on Language, Audio, & Music (GLAM), Imperial College London, London, U.K.; a Full Professor and the Chair of Embedded Intelligence for Health Care and Wellbeing, University of Augsburg, Augsburg, Germany; and the Co-Founding CEO and CSO of audEERING. He is also an Independent Research Leader with The Alan Turing Institute—Royal Statistical Society Laboratory, U.K. Health Security Agency, leading research on COVID-19. He frequently consults Barclays, GN, Huawei, Informetis, or Samsung. He has coauthored five books and more than 1200 publications (45 k citations, H-index 97).

Dr. Schuller is the Field Chief Editor of *Frontiers in Digital Health*, a former Editor-in-Chief of IEEE TRANSACTIONS ON AFFECTIVE COMPUTING, the President-Emeritus and Fellow of the Association for the Advancement of Affective Computing, the Golden Core Awardee of the IEEE Computer Society, a Fellow of the British Computer Society, the International Speech Communication Association, and the European Laboratory for Learning and Intelligent Systems Society, and a Senior Member of ACM.

Johanna Löchner studied psychology at Philipps-University Marburg, Marburg, Germany, and the Universidad de Monterrey, San Pedro Garza García, Mexico. She received the Ph.D. degree in clinical psychology from the Department of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy, Ludwig-Maximilians-Universität München (LMU), Munich, Germany.

She did her Post-Doctoral Fellowship with the Department of Clinical Psychology and Psychotherapy, LMU. From 2020 to 2022, she was the Head of the National Center for Early Prevention, German Youth Institute e.V. She is a licensed psychotherapist (Cognitive Behavioral Therapy, CBT) treating children, adolescents, and adults since 2012 at inpatient and outpatient centers [e.g., Clinic for Psychiatry, Psychosomatics and Psychotherapy of the LMU; psychosomatic outpatient clinic of the Klinikum rechts der Isar, Technical University of Munich (TUM), Munich]. Since 2022, she has been a Junior Professor for e-mental health and mobile assessment with the Department of Child and Adolescent Psychiatry, University Hospital Tübingen, Tübingen, Germany. She is also a Lecturer for psychotherapists in training (CBT).

Dr. Löchner is a Full Member of the German Society for Psychology and Arbeitsgemeinschaft für Verhaltensmodifikation e.V.

Kun Qian (Senior Member, IEEE) received the doctoral degree for his study on automatic general audio signal classification in electrical engineering and information technology from Technische Universität München (TUM), Munich, Germany, in 2018.

Since 2021, he has been a (Full) Professor with Beijing Institute of Technology, Beijing, China. He has a strong collaboration connection to prestigious universities in Germany, United Kingdom, Japan, Singapore, and the United States. He has coauthored more than 90 publications in peer-reviewed journals and conference proceedings, having received more than 1400 citations (H-index 21).

Dr. Qian serves as an Associate Editor for IEEE TRANSACTIONS ON AFFECTIVE COMPUTING, *Frontiers in Digital Health*, and *BIO Integration*.

Bin Hu received the Ph.D. degree in computer science from the Institute of Computing Technology, Chinese Academy of Science, Beijing, China, in 1998.

He is currently a Professor and the Dean of the School of Medical Technology and the Institute of Engineering Medicine, Beijing Institute of Technology, Beijing. He is also an Adjunct Professor and the former Dean of the School of Information Science and Engineering, Lanzhou University, Lanzhou, China. He is a National Distinguished Expert, the Chief Scientist of 973, as well as the National Advanced Worker in 2020.

Dr. Hu is a Fellow of the Institution of Engineering and Technology (IET). He is a member of the Steering Council of the ACM China Council and the Vice-Chair of the China Committee of the International Society for Social Neuroscience. He serves as the Editor-in-Chief for IEEE TRANSACTIONS ON COMPUTATIONAL SOCIAL SYSTEMS. He is also the TC Co-Chair of computational psychophysiology in the IEEE Systems, Man, and Cybernetics Society (SMC) and the TC Co-Chair of cognitive computing in IEEE SMC. He is a member of the Steering Committee of Computer Science, Chinese Ministry of Education, and the Science and Technology Commission, Chinese Ministry of Education. His awards include the 2014 China Overseas Innovation Talent Award, the 2016 Chinese Ministry of Education Technology Invention Award, the 2018 Chinese National Technology Invention Award, and the 2019 WIPO-CNIPA Award for Chinese Outstanding Patented Invention. He is a Principal Investigator for large grants such as the National Transformative Technology "Early Recognition and Intervention Technology of Mental Disorders Based on Psychophysiological Multimodal Information," which have greatly promoted the development of objective, quantitative diagnosis and nondrug interventions for mental disorders.