

# *Explanatory and Illustrative Visualization of Special and General Relativity*

**A1 -**

**A2 -**

*This paper describes methods for explanatory and illustrative visualizations used to communicate aspects of Einstein's theories of special and general relativity, their geometric structure, and of the related fields of cosmology and astrophysics. Our illustrations target a general audience of laypersons interested in relativity. We discuss visualization strategies, motivated by physics education and the didactics of mathematics, and describe what kind of visualization methods have proven to be useful for different types of media, such as still images in popular science magazines, film contributions to TV shows, oral presentations, or interactive museum installations.*

**A3 -**

*Our primary approach is to adopt an egocentric point of view: The recipients of a visualization participate in a visually enriched thought experiment that allows them to experience or explore a relativistic scenario. In addition, we often combine egocentric visualizations with more abstract illustrations based on an outside view in order to provide several presentations of the same phenomenon. Although our visualization tools often build upon existing methods and implementations, the underlying techniques have been improved by several novel technical contributions like image-based special relativistic rendering on GPUs, special relativistic 4D ray tracing for accelerating scene objects, an extension of general relativistic ray tracing to manifolds described by multiple charts, GPU-based interactive visualization of gravitational light deflection, as well as planetary terrain rendering.*

**A4 -**

*The usefulness and effectiveness of our visualizations are demonstrated by reporting on experiences with, and feedback from, recipients of visualizations and collaborators.*

**A5 -**

## *Acuity-Driven Gigapixel Visualization*

**A1 -**

**A2 -**

*We present a framework for acuity-driven visualization of super-high resolution image data on gigapixel displays.*

**A3 -**

*Tiled display walls offer a large workspace that can be navigated physically by the user. Based on head tracking information, the physical characteristics of the tiled display and the formulation of visual acuity, we guide an out-of-core gigapixel rendering scheme by delivering high levels of detail only in places where it is perceivable to the user. We apply this principle to gigapixel image rendering through adaptive level of detail selection. Additionally, we have developed an acuity-driven tessellation scheme for high-quality Focus-and-Context (F+C) lenses that significantly reduces visual artifacts while accurately capturing the underlying lens function. We demonstrate this framework on the Reality Deck, an immersive gigapixel display*

**A4 -**

*We present the results of a user study designed to quantify the impact of our acuity-driven rendering optimizations in the visual exploration process.*

**A5 -**

*We discovered no evidence*

*suggesting a difference in search task performance between our framework and naive rendering of gigapixel resolution data, while realizing significant benefits in terms of data transfer overhead. Additionally, we show that our acuity-driven tessellation scheme offers substantially increased frame rates when compared to naive pre-tessellation, while providing indistinguishable image quality.*

# *A Survey on Auto-Parallelism of Large-Scale Deep Learning Training*

## **A1 -**

*Deep learning (DL) has gained great success in recent years, leading to state-of-the-art performance in research community and industrial fields like computer vision and natural language processing. One of the reasons for this success is the huge amount parameters adopted in DL models.*

## **A2 -**

*However, it is impractical to train a moderately large model with a large number of parameters on a typical single device. Thus, It is necessary to train DL models in clusters with distributed training algorithms. However, traditional distributed training algorithms are usually sub-optimal and highly customized, which owns the drawbacks to train large-scale DL models in varying computing clusters. To handle the above problem, researchers propose auto-parallelism, which is promising to train large-scale DL models efficiently and practically in various computing clusters.*

## **A3 -**

*In this survey, we perform a broad and thorough investigation on challenges, basis, and strategy searching methods of auto-parallelism in DL training. First, we abstract basic parallelism schemes with their communication cost and memory consumption in DL training. Further, we analyze and compare a series of current auto-parallelism works and investigate strategies and searching methods which are commonly used in practice. At last, we discuss several trends in auto-parallelism which are promising in further research.*

## **A4 -**

## **A5 -**

# *A Scalable Multi-Layer PBFT Consensus for Blockchain*

## A1 -

*Abstract—Practical Byzantine Fault Tolerance (PBFT) consensus mechanism shows a great potential to break the performance bottleneck of the Proof-of-Work (PoW)-based blockchain systems, which typically support only dozens of transactions per second and require minutes to hours for transaction confirmation. However, due to frequent inter-node communications, PBFT mechanism has a poor*

## A2 -

*node scalability and thus it is typically adopted in small networks. To enable PBFT in large systems such as massive Internet of Things (IoT) ecosystems and blockchain, in this article, a scalable multi-layer PBFT-based consensus mechanism is proposed by hierarchically grouping nodes into different layers and limiting the communication within the group.*

## A3 -

*We first propose an optimal double-layer PBFT and show that the communication complexity is significantly reduced. Specifically, we prove that when the nodes are evenly distributed within the sub-groups in the second layer, the communication complexity is minimized. The security threshold is analyzed based on faulty probability determined (FPD) and faulty number determined (FND) models, respectively. We also provide a practical protocol for the proposed double-layer PBFT system.*

## A4 -

*Finally, the results are extended to arbitrary-layer PBFT systems with communication complexity and security analysis.*

## A5 -

*Simulation results verify the effectiveness of the analytical results.*

# *A Framework for Linear Information Inequalities*

## A1 -

## A2 -

*We present a framework for information inequalities, namely, inequalities involving only Shannon's information measures, for discrete random variables.*

## A3 -

*A region in  $\mathbb{R}_2^{\geq 1}$ , denoted by  $\mathcal{I}_n$ , is identified to be the origin of all information inequalities involving  $n$  random variables in the sense that all such inequalities are partial characterizations of  $\mathcal{I}_n$ . A product from this framework is a simple calculus for verifying all unconstrained and constrained linear information identities and inequalities which can be proved by conventional techniques. These include all information identities and inequalities of such types in the literature.*

## A4 -

*As a consequence of this work, most identities and inequalities involving a definite number of random variables can now be verified by a software called ITIP which is available on*

*the World Wide Web.*

## **A5 -**

*Our work suggests the possibility of the existence of information inequalities which cannot be proved by conventional techniques. We also point out the relation between [?] and some important problems in probability theory and information theory.*

# ***AVoiD-DF: Audio-Visual Joint Learning for Detecting Deepfake***

## **A1 -**

*Recently, deepfakes have raised severe concerns about the authenticity of online media. Prior works for deepfake detection have made many efforts to capture the intramodal artifacts. However, deepfake videos in real-world scenarios often consist of a combination of audio and visual.*

## **A2 -**

*In this paper, we propose an Audio-Visual Joint Learning for Detecting Deepfake (AVoiD-DF), which exploits audio-visual inconsistency for multi-modal forgery detection.*

## **A3 -**

*Specifically, AVoiD-DF begins by embedding temporal-spatial information in Temporal-Spatial Encoder. A Multi-Modal Joint-Decoder is then designed to fuse multi-modal features and jointly learn inherent relationships. Afterward, a Cross-Modal Classifier is devised to detect manipulation with inter-modal and intra-modal disharmony. Since existing datasets for deepfake detection mainly focus on one modality and only cover a few forgery methods, we build a novel benchmark DefakeAVMiT for multi-modal deepfake detection. DefakeAVMiT contains sufficient visuals with corresponding audios, where any one of the modalities may be maliciously modified by multiple deepfake methods.*

## **A4 -**

## **A5 -**

*The experimental results on DefakeAVMiT, FakeAVCeleb, and DFDC demonstrate that the AVoiD-DF outperforms many state-of-the-arts in deepfake detection. Our proposed method also yields superior generalization on various forgery techniques.*

# *An Efficient Privacy-Enhancing Cross-Silo Federated Learning and Applications for False Data Injection Attack Detection in Smart Grids*

## **A1 -**

*Clustering algorithms have emerged as an alternative powerful meta-learning tool to accurately analyze the massive volume of data generated by modern applications. In particular, their main goal is to categorize data into clusters such that objects are grouped in the same cluster when they are similar according to specific metrics. There is a vast body of knowledge in the area of clustering and there has been attempts to analyze and categorize them for a larger number of applications. However, one of the major issues in using clustering algorithms for big data that causes confusion amongst practitioners is the lack of consensus in the definition of their properties as well as a lack of formal categorization.*

## **A2 -**

*With the intention of alleviating these problems, this paper introduces concepts and algorithms related to clustering, a concise survey of existing (clustering) algorithms as well as providing a comparison, both from a theoretical and an empirical perspective.*

## **A3 -**

*From a theoretical perspective, we developed a categorizing framework based on the main properties pointed out in previous studies. Empirically, we conducted extensive experiments where we compared the most representative algorithm from each of the categories using a large number of real (big) data sets.*

## **A4 -**

*The effectiveness of the candidate clustering algorithms is measured through a number of internal and external validity metrics, stability, runtime, and scalability tests. In addition, we highlighted the set of clustering algorithms that are the best performing for big data.*

## **A5 -**

## *A Survey of Incentive Mechanism Design for Federated Learning*

## **A1 -**

*Federated learning is promising in enabling large-scale machine learning by massive clients without exposing their raw data. It can not only enable the clients to preserve the privacy information, but also achieve high learning performance. Existing works of federated learning mainly focus on improving learning performance in terms of model accuracy and learning task completion time. However, in practice,*

*clients are reluctant to participate in the learning process without receiving compensation.*

## **A2 -**

*Therefore, how to*

*effectively motivate the clients to actively and reliably participate in federated learning is paramount. As compared to the current incentive mechanism design in other fields, such as crowdsourcing, cloud computing, smart grid, etc., the incentive mechanism for federated learning is more challenging. First, it is hard to evaluate the training data value of each client. Second, it is difficult to model the learning performance of different federated learning algorithms.*

## **A3 -**

*In this article, we survey the incentive mechanism design for federated learning.*

*In particular, we present a taxonomy of existing incentive mechanisms for federated learning, which are subsequently discussed in depth by comparing and contrasting different approaches. Finally, some future directions of how to incentivize clients in federated learning have been discussed.*

## **A4 -**

## **A5 -**

# ***A Mental Health Chatbot for Regulating Emotions (SERMO) - Concept and Usability Test***

## **A1 -**

*Mental disorders are widespread in countries all over the world. Nevertheless, there is a global shortage in human resources delivering mental health services. Leaving people with mental disorders untreated may increase suicide attempts and mortality. To address this matter of limited resources, conversational agents have gained momentum in the last years.*

## **A2 -**

*In this work, we introduce SERMO, a mobile*

*application with integrated chatbot that implements methods from cognitive behaviour therapy (CBT) to support mentally ill people in regulating emotions and dealing with thoughts and feelings. SERMO asks the user on a daily basis on events that occurred and on emotions. It determines automatically the basic emotion of a user from the natural language input using natural language processing and a lexicon-based approach. Depending on the emotion, an appropriate measurement such as activities or mindfulness exercises are suggested by SERMO.*

## **A3 -**

*Additional functionalities are an emotion diary, a list of pleasant activities, mindfulness exercises and information on emotions and CBT in general.*

## **A4 -**

*User experience was studied with*

*21 participants using the User Experience Questionnaire (UEQ). Findings show that efficiency, perspicuity*

*and attractiveness are considered as good. The scales describing hedonic quality (stimulation and novelty), i.e., fun of use, show neutral evaluations.*

**A5 -**