The 7th International Conference on Ubiquitous Positioning, Indoor Navigation and Location-Based Services（UPINLBS 2022）

Brain-inspired Navigation Workshop

（1 Keynote + 5 Invited Talks + 2 Papers）

With the continuous expansion of the application scope of intelligent robots, many new challenges and difficulties are brought to the intelligent navigation and positioning technology. However, humans and animals in nature have excellent advanced cognitive navigation capabilities including intelligent spatial positioning, mapping, navigation, memory, and decision-making. In recent years, neuroscientists have gradually discovered the "brain's GPS system", including place cells, grid cells, and head-oriented cells, etc. The neural mechanism of spatial navigation and positioning in the brain with capabilities of high-efficiency, low-energy, robustness, and super-intelligence provides many inspirations and theoretical basis for us to develop new brain-inspired intelligent navigation and positioning technologies. In recent years, by drawing on the neural mechanisms of human and biological brains such as environmental perception, spatial learning, map memory, path decision-making, and spatial reasoning, the development of novel brain-inspired navigation theories and methods and cutting-edge technologies have attracted great attention from scholars in multidisciplinary fields. The brain-inspired navigation has become one of the frontier topics in the field of neuroscience and brain-inspired intelligence, which provides a new technical idea for the development of a new generation of intelligent navigation and positioning technology, and has important scientific significance and application value.

Workshop Topics：

1. Brain-inspired SLAM and Navigation
2. Brain-inspired Computing Chip
3. Brain-inspired Intelligent Robotics

Organizers

1. Professor Fuqiang Gu，Chongqing University, email: gufq@cqu.edu.cn

Fuqiang Gu, Professor of College of Computer Science, Chongqing University. He got his PhD from the University of Melbourne. He is a member of IEEE, ACM, and CCF. He worked at the RWTH Aachen University, University of Toronto, and National University of Singapore. His research interests include navigation and positioning, machine learning, robotics, brain-like intelligence, etc. He has published in many leading journals and conferences such as TVT, CSUR, TIM, IoT, FGCS, IJCAI, GLOBECOM, and IROS. He is funded by NSFC, DAAD, and so on.

2. Dr. Fangwen Yu，Tsinghua University, email: yufangwen@tsinghua.edu.cn

Fangwen Yu currently works as a Postdoctoral Research Fellow in the Center for Brain-Inspired Computing Research at Tsinghua University. He got his PhD from the China University of Geosciences, Wuhan. He was a visiting PhD student at Queensland University of Technology (QUT). He is a member of IEEE-RAS Technical Committee on Cognitive Robotics and Neuro-robotics Systems, the Cognitive Navigation Group at the Royal Institute of Navigation (RIN), etc. His research interests include brain-inspired 3D navigation, brain-inspired robotics, brain-inspired computing system, etc. His research models the neural mechanisms in the brain underlying tasks like 3D navigation and 3D spatial cognition to develop new neuromorphic 3D SLAM and 3D cognitive navigation technologies for space, air, land, sea-based autonomous robots and vehicles. He was awarded the Innovation Grand Prize at ICCBC 2019, the Innovation Award of 6th Hubei Province "Changjiang Student", Excellent Doctoral Thesis, UPINLBS 2016 Best Paper Award, etc.

Invited Talks

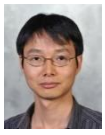
1. Professor Michael Milford， Queensland University of Technology，Email：michael.milford@qut.edu.au Keynote Speech

Title: Neuroscience-inspired SLAM and navigation: Where are we coming from and where could we go?

10:50a.m. – 11:30a.m. March 18, Friday

Professor Milford conducts interdisciplinary research at the boundary between robotics, neuroscience and computer vision and is a multi-award winning educational entrepreneur. His research models the neural mechanisms in the brain underlying tasks like navigation and perception to develop new technologies in challenging application domains such as all-weather, anytime positioning for autonomous vehicles. He is also passionate about engaging and educating all sectors of society around new opportunities and impacts from technology including robotics, autonomous vehicles and artificial intelligence. Michael currently holds the positions of Australian Research Council Laureate Fellow, Joint Director of the QUT Centre for Robotics, QUT Professor, Microsoft Research Faculty Fellow and is a former Chief Investigator at the Australian Centre for Robotic Vision.

Abstract: In this talk, I will briefly overview our work in neuroscience-inspired robotic mapping and navigation, and discuss five key questions and open research areas, linking into past and recent neuroscience and biological discoveries: The Loop Closure Question, the 3D Question, the Probabilistic Question, the Multi-Scale Question, and the Behavioral Question.



2. Professor Bailu Si，Beijing Normal University，email：bailusi@bnu.edu.cn

Title: Cognitive mapping based on geometry representations

13:30 – 13:50, March 18, Friday

Bailu Si, Professor of the School of Systems Science, Beijing Normal University and Chinese Institute for Brain Research Beijing. He serves as committee members of the

Beijing Association of Brainnetome and Brain-inspired Intelligence, Computational Neuroscience and Neuroengineering Association of Chinese Neuroscience Society. His research interest focuses on computational neuroscience and brain-inspired robotics. His main work includes computational theory of memory circuits, brain-inspired navigation systems.

3. Assistant Professor Lei Deng, Tsinghua University，email：leideng@mail.tsinghua.edu.cn

Title: Brain-inspired Computing Chip and Robots

13:50 – 14:10, March 18, Friday

Lei Deng received the B.E. degree from University of Science and Technology of China, Hefei, China in 2012, and the Ph.D. degree from Tsinghua University, Beijing, China in 2017. He was a Postdoctoral Fellow at the Department of Electrical and Computer Engineering, University of California, Santa Barbara, CA, USA from 2017 to 2021. He is currently an Assistant Professor at Center for Brain Inspired Computing Research (CBICR), Tsinghua University, Beijing, China. His research interests span the area of brain-inspired computing, neuromorphic chip, machine learning, and computer architecture. He has published over 80 peer reviewed journal/conference papers including Nature (cover) series, JSSC, JSTSP (cover), PIEEE, IEEE/ACM Transactions, ICML, ICLR, AAAI, NeurIPS, HPCA, ASPLOS, DATE, etc., and over 30 China/US patents. He was a recipient of the 2021 Outstanding Young Scholar of NSFC, 2021 Outstanding Youth Award of CAAI, 2021 Young Scholar for Brain Research, Beijing, and 2019 MIT Technology Review Innovators Under 35 China. He served as a Guest Associate Editor for Frontiers in Neuroscience and Frontiers in Computational Neuroscience, a PC Member for IJCNN2021, ASAP2021 and ISNN2019, and a reviewer for a number of journals and conferences. His representative achievement, Tianjic neuromorphic chip and the unmanned bicycle, was published in Nature as a cover story, which was selected into the 2019 Top-10 Chinese Scientific and Technological Advances, Top-10 Chinese Scientific Advances, Top-15 World Leading Internet Scientific and Technological Achievements, and received the 2020 Leading Award of Chinese Robotics.

4. Chuang Yang, PhD Candidate，Nanjing University of Aeronautics and Astronautics & National University of Singapore，email：yangchuang@nuaa.edu.cn

Title: Brain-inspired Navigation for UAV Swarm Working in GNSS-denied Environment

14:10 – 14:30, March 18, Friday

Chuang Yang is currently a visiting PhD student at Department of Electrical and Computer Engineering, National University of Singapore, funded by China Scholarship Council. He is also a PhD student at College of Automation Engineering, Nanjing University of Aeronautics and Astronautics, China. His research interests include brain-inspired navigation and decision-making for aerial vehicles, inertial-based integrated navigation, and brain-inspired computing. He is a member of Royal Institute of Navigation, Chinese Association for Artificial Intelligence, Chinese Neuroscience Society, Chinese Association of Automation, and Chinese Society of Aeronautics and Astronautics. He is also a Journal

Reviewer of IEEE Transactions on Industrial Electronics, Chinese Journal of Aeronautics, and Aircraft Engineering and Aerospace Technology.

5. Dr. Zhenshan Bing，Senior Researcher, Technical University of Munich, Germany，email：bing@in.tum.de

Title: Towards Cognitive Navigation: A Biologically Inspired Calibration Mechanism for the Head Direction Cell Network

15:10 – 15:30, March 18, Friday

Dr. Zhenshan Bing is a senior researcher at the Technical University of Munich, Germany. His research interests include biomimetic robots, brain-inspired navigation algorithm, and reinforcement learning. He has published over 30 peer-reviewed papers on top-level journals and conferences. He severs as the project coordinator of the Sino-DFG Mobility Program and the KI.FABRIK Bavaria research and development project. He also serves as the associate editor of the journal Frontiers in Neurorobotics and Cyborg and Bionic Systems.

6. Guangzhi Tang, Ph.D. Candidate， Rutgers University, USA， email：gt235@cs.rutgers.edu

Title: Biologically Inspired Spiking Neural Networks for Energy-Efficient Robot Navigation and Control

15:30 – 15:50, March 18, Friday

Guangzhi Tang is a Ph.D. candidate in the Department of Computer Science at Rutgers, the State University of New Jersey. His research focuses on neuromorphic computing and neurorobotics, specifically on designing energy-efficient solutions for robot navigation, control, and learning using spiking neural networks. He is a member of the Computational Brain Lab (Combra) at Rutgers University and has been interned at the Neuromorphic Computing Lab (NCL) at Intel Labs.

Abstract: Energy-efficient navigation and control are crucial for autonomous mobile robots as they explore unknown environments and solve real-world tasks with limited on-board resources. To exhibit fully autonomous behavior, mobile robots need to understand the environments by solving the localization and mapping problem and performing goal-directed control solely based on sensory observations. We propose Spiking Neural Networks (SNNs) for energy-efficient navigation and control on the neuromorphic processor. First, we present a biologically constrained SNN, inspired by the brain's spatial system, solving the unidimensional localization and mapping problem while only consuming 1% of dynamic power compared with the conventional approach. Then, we propose a hybrid reinforcement co-learning framework that jointly trains deep neural networks and SNNs to learn optimal controls for mobile robot navigation and high-dimensional continuous control. These works pave the way towards an alternative solution for autonomous robots fully controlled by neuromorphic processors.

投稿论文报告：

14:30 – 14:50	Miao Dong, Haiyang Qiu, Hui Wang, Peng fei Zhi and Zihao Xu (Jiangsu University of Science and Technology)	Sonar Image Recognition Based on Machine Learning Framework
15:50 – 16:10	Feifan Zhang, Wei Ke and Hongxin Ouyang (Nanjing Normal University)	Indoor Visible Light Localization Method Based on Embedded Artificial intelligence

第七届普适定位、室内导航与基于位置服务国际会议（UPINLBS 2022）

类脑导航分论坛

（1 Keynote + 5 Invited Talks + 2 Papers）

随着智能机器人应用范围的不断拓展，对智能导航定位技术也带来许多新的挑战和难题。然而，自然界中的人类和动物等却具有卓越的智能空间定位、制图、导航、记忆、决策等高级认知导航能力。近年来神经科学家们逐渐发现了“大脑中的 GPS 系统”，包括位置细胞、网格细胞、头朝向细胞等。大脑这种高效率、低能耗、强鲁棒、超智能的空间导航定位神经机制，为我们开发新的类脑智能导航定位技术提供了重要灵感和理论基础。近年来，通过借鉴人类和生物大脑环境感知、空间学习、地图记忆、路径决策、空间推理等神经机制，发展新型类脑导航理论方法和前沿技术受到多学科领域学者的高度关注，也逐渐成为脑科学与类脑智能领域的前沿热点方向之一，为发展新一代智能导航定位技术提供了全新的技术思路，具有重要的科学意义和应用价值。

分论坛主题：

1. 类脑定位、制图与导航
2. 类脑计算芯片
3. 类脑智能机器人

分论坛召集人

1. 古富强 教授， 重庆大学 邮箱 gufq@cqu.edu.cn

古富强，重庆大学计算机学院教授、博导，墨尔本大学博士，IEEE/ACM/CCF 会员。曾先后在德国亚琛工业大学、加拿大多伦多大学、新加坡国立大学从事研究工作。研究方向包括导航定位、机器学习、机器人、类脑智能等。相关研究成果发表于 TVT、CSUR、TIM、IoT、FGCS、IJCAI、GLOBECOM、IROS 等国际主流期刊及会议。主持了国家自然科学基金面上项目、德国 DAAD 研究基金项目等。

2. 余芳文 博士后， 清华大学 邮箱 yufangwen@tsinghua.edu.cn

余芳文，清华大学类脑计算研究中心博士后。博士毕业于中国地质大学（武汉），博士期间在澳大利亚昆士兰科技大学访学 2 年。现担任 IEEE 机器人与自动化协会认知机器人技术委员会、类脑机器人技术委员会，英国皇家导航协会（RIN）

认知导航组，中国人工智能学会科普工作委员会等委会。研究兴趣包括类脑三维导航、类脑机器人、类脑计算系统等。目前主持中国博士后面上基金项目 1 项，参与“中国脑计划”重大专项、国家自然科学基金重点项目、原创探索计划项目等多项类脑计算相关课题。近年来借鉴大脑三维导航神经机理研发出了一套面向智能机器人的类脑三维同步定位与制图系统 NeuroSLAM。曾荣获 2019 年国际大学生类脑计算大赛创新特等奖、2020 年湖北省“长江学子”开拓创新奖、校优秀博士学位论文、全国高校 GIS 新秀、UPINLBS 2016 最佳论文奖等。

确认特邀专家

1. Professor Michael Milford， Queensland University of Technology，Email：michael.milford@qut.edu.au

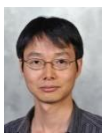
题目：类脑 SLAM 和导航：进展与展望　大会特邀报告

Title: Neuroscience-inspired SLAM and navigation: Where are we coming from and where could we go?

10:50a.m. – 11:30a.m. March 18, Friday

Professor Milford conducts interdisciplinary research at the boundary between robotics, neuroscience and computer vision and is a multi-award winning educational entrepreneur. His research models the neural mechanisms in the brain underlying tasks like navigation and perception to develop new technologies in challenging application domains such as all-weather, anytime positioning for autonomous vehicles. He is also passionate about engaging and educating all sectors of society around new opportunities and impacts from technology including robotics, autonomous vehicles and artificial intelligence. Michael currently holds the positions of Australian Research Council Laureate Fellow, Joint Director of the QUT Centre for Robotics, QUT Professor, Microsoft Research Faculty Fellow and is a former Chief Investigator at the Australian Centre for Robotic Vision.

Abstract: In this talk, I will briefly overview our work in neuroscience-inspired robotic mapping and navigation, and discuss five key questions and open research areas, linking into past and recent neuroscience and biological discoveries: The Loop Closure Question, the 3D Question, the Probabilistic Question, the Multi-Scale Question, and the Behavioral Question.



2. 斯白露 教授，北京师范大学，邮箱：bailusi@bnu.edu.cn

题目：基于环境几何表征的认知地图

Title: Cognitive mapping based on geometry representations

13:30 – 13:50, March 18, Friday

斯白露，北京师范大学系统科学学院教授，北京脑中心北脑学者。任北京脑网络组与类脑智能学会理事，中国神经科学学会计算神经科学和神经工程分会委员。主要研究领域包括计算神经科学、类脑机器人。代表性成果包括记忆神经环路的计算理论、类脑导航系统等。

3. 邓磊 助理教授，清华大学，邮箱：leideng@mail.tsinghua.edu.cn

题目：类脑计算芯片及机器人

Title: Brain-inspired Computing Chip and Robots

13:50 – 14:10, March 18, Friday

邓磊，清华大学助理教授，博士生导师，国家优青获得者。中国科学技术大学学士和清华大学博士，曾于美国加州大学圣塔芭芭拉分校（UCSB）攻读博士后。长期从事类脑计算、机器学习、芯片架构等领域的研究，迄今已在权威期刊 Nature（封面）及其子刊、JSSC、JSTSP（封面）、PIEEE、IEEE/ACM Transactions 等和顶级会议 ICML、ICLR、AAAI、NeurIPS、HPCA、ASPLOS、DATE 等发表学术论文 80 余篇，申请中国和美国发明专利 30 余项，曾担任国际期刊 Frontiers in Neuroscience 和 Frontiers in Computational Neuroscience 客座编辑以及国际会议 IJCNN2021、ASAP2021 和 ISNN 2019 程序委员会委员。入选 2021 年中国人工智能学会优青、2021 年北脑青年学者、2019 年《麻省理工科技评论》中国区 35 岁以下科技创新 35 人。代表成果“异构融合类脑计算芯片及无人驾驶自行车”发表于 Nature 封面，入选 2019 年两院院士评选中国十大科技进展、中国科学十大进展、15 项世界互联网领先科技成果和 2020 年中国机器人科学引领奖。

4. 杨闯 博士生，南京航空航天大学 & 新加坡国立大学，邮箱：yangchuang@nuaa.edu.cn

题目：卫星拒止环境下无人机集群类脑导航关键技术研究

Title: Brain-inspired Navigation for UAV Swarm Working in GNSS-denied Environment

14:10 – 14:30, March 18, Friday

杨闯，南京航空航天大学 & 新加坡国立大学联合培养博士研究生 (国家公派)。主要研究方向：飞行器集群类脑导航与决策，惯性基组合导航，类脑计算。Royal Institute of Navigation、中国人工智能学会、中国神经科学学会、中国自动化学会、中国航空学会等学会会员。IEEE Transactions on Industrial Electronics, Chinese Journal of Aeronautics, Aircraft Engineering and Aerospace Technology 等期刊审稿人。

5. 邴振山 高级研究员，德国慕尼黑工业大学，邮箱：bing@in.tum.de

题目：面向类脑导航：一种基于生物启发的头方向细胞校准机制研究

Title: Towards Cognitive Navigation: A Biologically Inspired Calibration Mechanism for the Head Direction Cell Network

15:10 – 15:30, March 18, Friday

邴振山，男，现任职德国慕尼黑工业大学高级研究员。主要从事仿生机器人、类脑算法、及基于强化学习的机器人运动控制等研究，在国际权威期刊发表学术论文 30 余篇。作为项目联合负责人主持国家自然科学基金中德合作交流项目、德国巴伐利亚州未来信息科技创新项目。现担任 Frontiers in Neurorobotics, Cyborg and Bionic Systems 等多个 SCI 期刊副编委，以及客座编委等职务。

6. 唐广智 博士生，美国罗格斯新泽西州立大学，邮箱：gt235@cs.rutgers.edu

题目：类脑脉冲神经网络在低能耗机器人导航和控制的应用

Title: Biologically Inspired Spiking Neural Networks for Energy-Efficient Robot Navigation and Control

15:30 – 15:50, March 18, Friday

唐广智，罗格斯新泽西州立大学计算机系博士候选人，脑计算实验室成员，曾于英特尔研究院类脑计算实验室从事实习研究。主要从事类脑计算和神经机器人的研究工作，具体的研究包括脉冲神经网络在低能耗机器人导航，控制，和学习领域的应用。

Abstract: Energy-efficient navigation and control are crucial for autonomous mobile robots as they explore unknown environments and solve real-world tasks with limited on-board resources. To exhibit fully autonomous behavior, mobile robots need to understand the environments by solving the localization and mapping problem and performing goal-directed control solely based on sensory observations. We propose Spiking Neural Networks (SNNs) for energy-efficient navigation and control on the neuromorphic processor. First, we present a biologically constrained SNN, inspired by the brain's spatial system, solving the unidimensional localization and mapping problem while only consuming 1% of dynamic power compared with the conventional approach. Then, we propose a hybrid reinforcement co-learning framework that jointly trains deep neural networks and SNNs to learn optimal controls for mobile robot navigation and high-dimensional continuous control. These works pave the way towards an alternative solution for autonomous robots fully controlled by neuromorphic processors.

投稿论文

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