Profiling China's AI Developers:

NUDT and Chinese Military Doctoral Research In Artificial Intelligence

Summary

China's People's Liberation Army (PLA) operates a number of universities, including the National University of Defense Technology (NUDT), its principal institution for high-technology education. NUDT offers a substantial graduate curriculum on artificial intelligence. In addition, this school operates a robust doctorate-level research base within its College of Computers that recent research indicates also has a significant focus on AI development.

Solicitations published in China in early 2020 for civilian doctoral students to join the NUDT research effort provided details on the specific research topics currently being pursued by NUDT. Of the eight doctoral research teams described in the solicitation, five were focused on AI development, including teams for:

NUDT's logo

Source: nudt.edu.cn

- **Machine learning and deep learning research**
- **Cyberspace security and artificial intelligence**
- **Computer architecture and artificial intelligence**
- **Artificial intelligence and unmanned aerial vehicle systems**
- **Artificial intelligence and big data processing**

Further investigation of this research effort identified AI-related academic papers by the leaders of these AI teams. Many of their recent works described the development of AI and deep learning mechanisms without directly connecting them to military systems. However, many of these publications did address the application of AI to combat operations, including discussion of the use of AI for **detection of enemy aircraft, object tracking by computer vision, weapons guidance, unmanned aerial vehicle autopilots,** and **tactical communication systems.** The NUDT work identified here suggests that this research may prefigure the direct application of AI to those military systems.

Background

For the past few months, China Keyhole research has been focused on developments in artificial intelligence by the Chinese military research infrastructure. As part of their efforts, the PLA established an Artificial Intelligence Research Center (AIRC) in 2017 as a lead element for research on AI-enabled weapons systems.[1] As indicated by their published research results, AIRC researchers have covered topics such as deep learning frameworks for robot operating systems, intelligent UAV (unmanned aerial vehicle) swarm networks, unmanned systems task management, and communications systems for UAV swarms and robot surveillance systems. This center appears to be the Chinese entity most focused on the application of AI-enabled systems to combat operations.

The data also showed that many of the key researchers at this center were graduates of the PLA's National University of Defense Technology in Changsha, China, the military's key high-technology school. A look at NUDT graduate programs showed a robust AI-related curriculum that can be applied directly to military intelligence analysis, target identification, autonomous weapons operations, and command control.[2] Thus it appears that this university is also contributing to military AI development through a strong AI technologies education program.

A further look at NUDT showed that the College of Computers at NUDT also serves as a major doctorate-level research base for the PLA with support to a broad range of AI research themes by their doctoral research advisers. Those identified as working in AI technologies have also published extensively on their efforts, and Chinese academic archives hold the papers they have published with the results of their research.

Seeing this element as also contributing to military AI development, the doctoral research programs of the NUDT College of Computers were examined for AI-related content, and the AI research leaders were profiled based on their published papers. The results of this look at NUDT are detailed below.

NUDT's Doctoral Research Programs

The online reference that provided the most detail on NUDT's doctoral research on AI came from a recruiting announcement. NUDT advertises each year for civilian applicants to join in their military research efforts. In February 2020, NUDT's College of Computers posted a description of their programs in such an advertisement, and it included the following information (the text below in blue frames about each team are translations of the posted Chinese data):

[1] See the China Keyhole Report: China's Military Artificial Intelligence Research Center, August 18, 2020.
[2] See the China Keyhole Report: NUDT and Chinese Military Education In Artificial Intelligence, September 24, 2020.

NUDT COLLEGE OF COMPUTERS
SPRING 2020 RECRUITING FOR CIVILIAN DOCTORAL STUDENTS
(SIGN UP CLOSING ON 20 FEBRUARY)

The NUDT College of Computers consists of four top-level science doctorate centers: computer science and technology, software engineering, cyberspace security, and electronic science and technology, plus mobile post-doctorate work centers on computer science and technology and software engineering. This college is mostly recruiting in these four disciplines, with graduate and doctorate research subsidies available for doctoral students. The teacher teams for the students we are currently recruiting are as follows:

Team 1: Machine Learning and Deep Learning Research
Team 2: Cyberspace Security and Artificial Intelligence
Team 3: Computer Architecture and Artificial Intelligence
Team 4: High Performance Computing
Team 5: Artificial Intelligence and Unmanned Aerial Vehicle Systems
Team 6: Symbolic Execution and Trusted Computing
Team 7: Artificial Intelligence and Big Data Processing
Team 8: Cyberspace Security (for selected doctoral students)

Perhaps the most notable aspect of the team list for these doctoral research program is that five of the eight teams (highlighted above **in blue text**) are dedicated to AI research. The leaders of all teams were identified in the solicitation and their core research areas described. Further details on the AI-related teams, as they appeared in the announcement, are spelled out below. In addition, searches were conducted for the published work by each of these team leaders to further define their research history over the past five years. The English-language abstracts from selections of their research are included below for the team leaders.

TEAM 1: MACHINE LEARNING AND DEEP LEARNING RESEARCH

Leadership: Professor **Zhu En (祝恩)**, email , phone 0731-84502131; and Professor **Liu Xinwang (刘新旺)**, email xinwangliu@nudt.edu.cn.

Research fields [for Zhu En]: artificial intelligence, machine learning, pattern recognition, and computer vision. Zhu En is a doctoral student adviser, the Secretary of the China Computer Foundation (CCF) Theoretical Computer Science Special Committee, Member of the CCF Artificial Intelligence and Pattern

Recognition Special Committee, and Executive Manager of the Hunan Province Computer Association. He has published more than 160 papers in academic publications and at conferences. He has been cited by nearly 30 national universities or scientific research entities and has published two papers in the journal Pattern Recognition that have together been cited 263 times.

Professor Liu Xinwang is a returned PhD [from education abroad]. His academic achievements in the machine learning field, including core learning algorithms, multi-vision learning, cluster and feature selection, and related learning algorithms, have had significant influence. Of the 28 works presenting his research results, 13 have been published in CCF-A level AAAI conferences (artificial intelligence field's top-level).

Zhu En

Source: research gate.net

Zhu En's published research for the past five years was reviewed, and this showed he has published on topics that include computer vision, data mining, computer education, fingerprint recognition, image processing, and object recognition. One of his papers, entitled "**Parallel Optimization Of Target Tracking Algorithms**" (目标跟踪算法的并行优化), published in 2016, touched on algorithm optimization for computer vision. A portion of the English abstract appears below (English abstracts that accompanied the articles are highlighted below in green frames).

"Object tracking is an important research area in computer vision. Researchers have proposed a number of excellent object tracking algorithms in recent years. However, the poor real-time performance of these algorithms restricts its effectiveness in application scenarios. Based on these algorithms, we design a general tracking model and propose a feasible parallel optimization scheme for the model. We also use the sparsity-based collaborative model (SCM) algorithm to validate the proposed scheme. In a four-core CPU environment, the parallel algorithm achieves a speedup of 3.48 times compared with the sequential algorithm, and it is about 30 times faster than the MATLAB+C program of the original algorithms, thus verifying the effectiveness of the proposed parallel optimization scheme."

Comments: It is unclear from the language used whether the "target tracking" being discussed refers to a physical target for tracking or attack rather than an object in a

series of images that is being "tracked" by the computer vision algorithm. The research appears focused on algorithm development, a more esoteric function than target tracking as part of combat operations.

Liu Xinwang

Source: xinwangliu.github.io

Liu Xinwang's published research has focused on machine learning, facial recognition, and network security. However, most of his papers were produced ten years ago or more. He may play a key role on this team, but he is less active than Zhu En in publishing recent work. One paper entitled "**A Kernel PCA View of the Local Tangent Space Alignment Algorithm**" (局部切空间对齐算法的核主成分分析解 释) published in 2010 shows something of the research he was conducting on machine learning at the time. A selection from the English abstract for this paper appears below.

> "Recently, nonlinear dimensionality reduction has attracted extensive interest of researchers in the machine learning community. The techniques for nonlinear dimensionality reduction can be divided into two categories: kernel-based methods and manifold learning. These two methods have different motivations and derivations. This paper interprets the well-known manifold learning algorithm LTSA as a kernel method. We show that LTSA can be described as the kernel PCA, and LTSA utilizes the local neighborhood information to construct a special kernel matrix, and the global embedding obtained by LTSA with modified constraints is equivalent to principal coordinates by the kernel PCA with this special kernel."

Comments: The strictly mathematical language used here again indicates that this work was most likely conducted at a fundamental AI-development level rather than in application of the technique to any specific form of military operations.

TEAM 2: CYBERSPACE SECURITY AND ARTIFICIAL INTELLIGENCE

Leadership: Professor **Cai Zhiping (蔡志平)**, email zpcai@nudt.edu.cn, phone 0731-4575804.

Research areas: network security, network monitoring, intelligent cloud, quantum machine learning, chemical reactions in neural network simulations, bio-information processing, big data mining and artificial intelligence. He is a

doctoral student adviser and Director of the NUDT Network Engineering Teaching and Research Office. He currently serves as Deputy Secretary of the CCF Theoretical Computer Expert Committee and the Internet Special Committee. He has served as a visiting professor at Toronto University in Canada, at the University of Florida in the USA, and at Hong Kong Polytechnic University.

Cai Zhiping

Source: icourses.cn

Cai Zhiping's published works show him to be a prolific researcher and writer. In the last five years, he has worked on a wide range of topics including cloud computing, computer vision, dispersed computing for military operations, education (course development), facial recognition, machine learning, internet of everything, network security, software defined networks, and wearable devices. One of his papers published in 2020, "**Dispersed Computing: Technology, Applications, And Challenges**" (分散计算：技术、应用与挑战), directly addressed the utility of these systems for military operations. The abstract appears below.

"In time-sensitive application scenarios such as military operations, cloud computing cannot meet users' real-time requirements, so dispersed computing comes into being. … Dispersed computing connects all devices with computing power to form a networked organism, with each computing node providing services to users in a collaborative and shared manner. Different from the localization processing of fog computing and edge computing, this mode makes use of the free computing power in the network, bypasses the limitation of local computing power, and has been widely concerned. This paper … introduces three core techniques of dispersed computing in detail. After that, this paper instantiates the concept of dispersed computing through some specific application scenarios, so as to better analyze the advantages of dispersed computing in the Internet of everything era. Finally, this paper presents several challenges and opportunities of dispersed computing."

Comments: This research appears to be more focused on application of the concept of dispersed computing rather than development of the technology itself. It shows that at least some of the work being done at NUDT is leading to practical applications.

TEAM 3: COMPUTER ARCHITECTURE AND ARTIFICIAL INTELLIGENCE

Leadership: Professor **Dou Yong (窦勇)**, email yongdou@nudt.edu.cn.

Research fields: high-performance computing, parallel and distributed processing, intelligent computing, artificial intelligence and computer vision, heterogeneous parallel systems architecture, and edge computing. Professor Dou is a doctoral student adviser, Director of the State Key Lab For Parallel and Distributed Processing, Director of the National Computer Architecture Special Committee, and winner of the National Natural Sciences Foundation's Outstanding Youth Foundation Award.

The team core includes Associate Professor **Jiang Jingfei (姜晶菲)**, emails jingfeijiang@nudt.edu.cn, jingfeijiang@yahoo.com.cn. She is a graduate student adviser and works in recruiting of civilian and military graduate students in the computer science and technology area. Her primary research fields include testing of computer architecture, configurable computing, high-performance implant computing, high-reliability computing, computing accelerators, AI chip design, heterogeneous systems architecture, and fault tolerance technology.

Dou Yong

Source: nsccsz.cn

Dou Yong is also a prolific researcher and has published research on algorithm development, biometrics, image processing, machine learning, object detection, and target detection. One of his 2017 projects, entitled "**Multi-Label Image Retrieval By Hashing With Object Proposal**" (目标提取与哈希机制的多标签图像检索), focused on AI applications to extract images of several objects from a single image. A portion of its abstract appears below.

"Objective Hashing is an effective means for large-scale image retrieval. Preserving the semantic similarity in hash codes (i. e., the distance between the hash codes of two images) should be small when the images are similar to improve the retrieval performance. This study proposes a new hash generation method with object proposals. We propose a new deep-network-based framework to construct hash functions that learn directly from images that contain multiple labels. The model first derives a series of interesting regions.

> that may contain objects and then generates the features of each region through deep convolutional neural networks. It finally generates a group of hash codes to describe all the objects in an image. The compact hash code will be generated to represent the entire image. A novel triplet-loss based training method is adopted to preserve the semantic order of the hash codes, … [and] experiment results show that the fine-grained feature embedding of an image is practicable."

Comments: Dou Yong's work, at least in this case, seems centered on computer vision algorithm development, with the practical application of such systems yet to be defined.

Jiang Jingfei

Source: bilibili.com

Jiang Jingfei's research has been more focused on AI employment in military systems than many of her contemporaries at NUDT. Over the past several years, she has conducted research on neural networks, object detection, target detection, and UAV control. One paper from 2015 that touched on AI-enabled military systems, "**Hardware Reinforcement Designs and Reliability Analysis of Unmanned Aerial Vehicle Autopilots**" (无人机自驾仪硬件加固方案设计与可靠性分析) , addressed software "repositors, counters, inverters, selectors, and additional codes inside the resolvers" designed to give greater stability to AI autopilot systems. One more recent work, "**Design and Implementation of Accelerator for Aircraft Key Points Detection Based on FPGA**" (基于 FPGA 的飞行器关键点检测加速器设计与实现), published in 2020, likewise describes the application of AI mechanisms to identifying target aircraft:

> "Remote-Sensing Aircraft Key Points Detection is important in route monitoring, airport management and target detection of enemy aircraft. The deep convolutional neural network (DNN) of VGG-19 has excellent performance in key points detection technology. Field-Programmable Gate Arrays (FPGAs) have been widely adopted to accelerate the inference of DNNs. In this paper, an FPGA-based processor design for aircraft key points detection is proposed to accelerate the detection and effectively process convolution, pooling and full connection operations."

Comments: Based on this abstract, it appears that this recent research, while dealing with optimization of an AI application, is tied directly to a military application: unmanned aircraft control.

TEAM 5: ARTIFICIAL INTELLIGENCE AND UNMANNED AERIAL VEHICLE SYSTEMS

Leadership: Professor **Luo Zhigang (骆志刚)**, e-mails zgluo@nudt.edu.cn, zhigang_luo@sina.com; cellphone 13807311725.

Research fields: computer vision, UAV systems, machine learning and pattern recognition, data mining, large-scale data processing.

Luo Zhigang

Source: baidu.com

Lou Zhigang's papers show that his research concentrations have been in DNA computing (exploring the use of artificially created DNA as a storage and processing medium), imagery processing, and object tracking, with direct references to military applications. His 2017 study, "**Status and Developments in Visual Object Tracking**" (视觉目标跟踪现状与发展), addressed the military applications that could use the tools of computer vision and object extraction from images:

"A visual object tracking system meets many application requirements in both military and civilian areas, such as weapons guidance, visual navigation, security monitor and so on. The goal of the visual object tracking is to accurately locate the objects in each frame and restore all objects' complete trajectories, respectively, which provides strong support for the decisions of high-level applications. … In this paper, we make a simple comparison to the algorithms of visual single/multiple objects tracking, and briefly analyze the pros and cons of the motioned algorithms."

TEAM 7: ARTIFICIAL INTELLIGENCE AND BIG DATA

Leadership: Professor **Li Dongshen (李东升)**, email lds1201@163.com.

Research fields: parallel computing and distributed processing, artificial intelligence and big data processing, deep learning and computer vision, and big data analysis.

Li Dongshen

Source: cvicse.com

A review of Li Dongshen's published research over the past five years showed work in communications systems, distributed processing, edge computing, image processing, and machine learning. One 2018 work that appeared directly applicable to military operations, "**Conflict Detection In Organization and Application Program Rules For Joint Tactical Communication System Based On Super Image**" (基于超图的联合战术通信系统组织运用方案规则库冲突检测), did not address communications systems per se but the AI problem of creating a good "rules-based conflict detection algorithm." His most recent published work, a 2020 paper entitled "**Learning To Select Pseudo Labels: a Semi-Supervised Method For Named Entity Recognition**" (学习挑选伪标签:一种用于命名实体识别的半监督学习方法), was focused on improving object recognition in machine learning:

> "Deep learning models have achieved state-of-the-art performance in named entity recognition (NER); the good performance, however, relies heavily on substantial amounts of labeled data. In some specific areas such as medical, financial, and military domains, labeled data is very scarce, while unlabeled data is readily available. In this study, we propose a semi-supervised method for NER tasks which learns to create high-quality labeled data by applying a pre-trained module to filter out erroneous pseudo labels. Pseudo labels are automatically generated for unlabeled data and used as if they were true labels. … Experimental results on two English NER tasks and one Chinese clinical NER task demonstrate that our method further improves the performance of the best single neural model."

Comments: The research as described in the abstract above appears again to be focused on improving the processes of machine learning without reference to a specific military application.

Additional Comments

Artificial intelligence is a rapidly developing field with its own vocabulary. The terminology used, even in the English-language abstracts of the papers described above, is not always intelligible to readers for whom AI mechanics is not a specialty. Therefore, trying to answer questions about the state of military AI development or what weapons systems are near-term goals for NUDT research remains a tough problem, even when NUDT research publications are readily available.

What seems obvious from the structure of NUDT's doctoral research program is that artificial intelligence is seen by the PLA as a key force enhancement tool, one in which they are willing to invest considerable resources, manpower, and time. This is indicated by the fact that the majority of the NUDT College of Computers teams assembled for doctoral research have an AI focus.

Much of the published research by NUDT team leaders appears to be on development of AI mechanisms rather than AI applications. In those works that describe "nonlinear dimensionality reduction," "hash generation," and "pseudo labels," when the research is on deep learning techniques and algorithm optimization, these efforts still seem **preliminary** to any application to military operations.

However, there were many research publications by the doctoral student advisers profiled above that addressed the **application** of AI to military systems. As described in these papers, the functions that this military AI research effort is striving toward include **detection of enemy aircraft, object tracking by computer vision, weapons guidance, unmanned aerial vehicle autopilots,** and **tactical communication systems.** If NUDT is in fact playing the role that it appears to be playing—a core development base for military AI—then this research may prefigure the direct application of AI to those military systems by other entities such as the Artificial Intelligence Research Center profiled in previous reporting.