RGC Ref. No.:
UGC/IDS14/16
(please insert ref. above)

RESEARCH GRANTS COUNCIL
COMPETITIVE RESEARCH FUNDING SCHEMES FOR
THE LOCAL SELF-FINANCING DEGREE SECTOR

INSTITUTIONAL DEVELOPMENT SCHEME (IDS)
RESEARCH INFRASTRUCTURE GRANT

Completion Report
(for completed projects only)

Submission Deadlines:	1. *Auditor's report with unspent balance, if any: within **six** months of the approved project completion date.*
	2. *Completion report: within **12** months of the approved project completion date.*

Important Note:
In completing the report, please use the following format:
Page limit: Items 1 to 5 and Summary of Completion Report: no page limit
             Items 6 to 9: maximum **20 A4 pages** (excluding any appendices and attachments)
Font: Times New Roman
Font Size: **Not smaller** than Point 12
Margin: Two centimeters margin all around
Spacing: Single-line spacing

1. **Project Title**

   Establishment of a Deep Learning Research & Application Centre (DLC)

2. **Investigator(s) and Academic Department(s) / Unit(s) Involved#**

Project Team	Name / Post	Department / Unit	Average Number of Hours Per Week Spent on this Project
Project holder* (i.e. Head of Institution)	Professor HO Shun-Man, Simon President of HSUHK	President's Office	1
Team leader	CHIN Yuk Lun, Francis Director of DLC (1 January 2018 – 31 July 2018) / Professor	Computing	10
	SIU Sai Cheong Director of DLC	Translation	10

	(1 August 2018 – 31 December 2019) / Associate Professor		
Team member(s)	SIU Yuk Tai, Trevor Professor	Communication	1
	CHAN Chi-Kong Lecturer	Computing	1
	LIU Hai Associate Director of DLC (1 August 2018 – 31 December 2019) / Associate Professor	Computing	5
	WONG Wai Kit Assistant Professor	Computing	1
	YANG Haiqin, Joseph Associate Director of DLC (1 January 2018 – 31 July 2018) / Assistant Professor (before 1 August 2018)/(Adjunct) Assistant Professor (since 1 August 2018)	Computing	1
	YUE Ho Yin, Willy Senior Lecturer	Computing	1
	WONG Po-Choi Director	ITSC	1
	LAM Shu Yan, Benson Assistant Professor	Mathematics & Statistics	1
	CHEUNG King Yin, Tommy Assistant Professor (before 1 August 2018) / Senior System Architect (Software) (1 August 2018 - February 2019)	Supply Chain & Information Management	1

Please state the **key** staff and department/unit involved in the project. Please add row(s) as necessary. Please also highlight the approved changes in project team composition and quote the date of the RGC approval for such changes.

* Refer to "Applicant" for 2015/16 exercise and "Project holder" for 2017/18 exercise onwards.

> NOTE:
> In 2017, two team members in the original proposal Dr CHUI Kam Hung, David (Economics and Finance) and Dr WONG Wai Hung, Collin (Supply Chain & Information Management) resigned and were replaced by Dr CHEUNG King Yin Tommy (who later left the Hang Seng University of Hong Kong (HSUHK) in February 2019) and Dr YANG Haiqin. RGC approval was given for this change in project team composition on 17 July 2017.
>
> Professor CHIN Yuk Lun, Francis, the previous team leader, left the then Hang Seng Management College (HSMC) on 1 August 2018. A request for change of Team leader was made on 30 May 2018 and was approved on 29 June 2018.

3. Project Duration

	Original	**Revised**	**Date of RGC / Institution Approval** *(must be quoted)*
Project Start Date	January 1, 2017	- No change -	
Project Completion Date	December 31, 2019	- No change -	
Duration *(in month)*	36	- No change -	
Deadline for Submission of Completion Report	December 31, 2020	- No change -	

4. Project Objectives

Summary of objectives addressed / achieved:

Objectives*	**Percentage Achieved**	**Remarks****
1. To develop a flexible, reliable and efficient computing environment for Deep Learning;	100%	
2. To educate researchers in the College (and students who are interested) so that they may understand, and possibly apply, Deep Learning in their research projects;	100%	
3. To identify and promote research projects with innovative applications and potential, which will make good use of the Centre's resources;	100%	
4. To collaborate with other organizations, such as ASTRI, for various innovative the Deep Learning applications; and	100%	
5. To disseminate, in Hong Kong and elsewhere, the experience and results of applying Deep Learning innovatively to various problems in different domains.	100%	

* *Please refer to the originally approved objectives. If there are changes in objectives, please highlight the changes and quote the date of RGC approval for such changes.*
** *Please provide reasons for significant slower rate of progress when compared with the approved implementation timetable.*

> NOTE: Upon approving this Project, the RGC cut the budget significantly from $14M to around $7M. Consequently, the objective of "establishing a hub of specialists in the area of

Deep Learning and Tensorflow" in the original Proposal was eliminated following the cut in budget in the revised Proposal approved by the RGC on 3 January 2017.

6.   Research Outputs

6.1   What are the accomplishments of the project?

(i)   Please provide reports on conference, seminar, workshop, exchange programmes or other activities held (if applicable).
(Please provide details of the activities organized, including the theme / objectives of the activities, targeted participants, attendance, analysis of participants, e.g. country of origin, research background, etc., evaluation forms of the activities and a summary of the participants' evaluation.   Photos of the activities are preferred.)

In addition to organising the 2 tutorials, 5 workshops, and a conference stated in the proposal, we held extra workshops and delivered talks to further promote Deep Learning and its research and applications. Please see below our full list of activities over the past years:

Tutorial: What is Deep Learning and why it matters?
The tutorial, which was held on 23 May 2017 and attracted 36 participants, aimed to explain how computers learn and the recent breakthroughs in Deep Learning which affect our life in many aspects and to discuss the role of the Deep Learning Research and Application Centre and potential research areas that might benefit from the new

technology. The participants gave an average score of 5.51 out of 6 for the tutorial.

Tutorial: Deep Learning & Research Interest
This tutorial was held on 1 June 2017 and attracted 57 participants. It provided an opportunity for researchers to share their inter-disciplinary projects of deep learning and seek future collaboration with others We mainly received positive feedback for this sharing session. Our respondents gave an average score of 4.5 out of 5 for the overall organization and atmosphere of the entire sharing session. More than 80% of our respondents praised that there are clear goals in this event. Furthermore, nearly all of them agreed or strongly agreed that the sharing session has provided them an opportunity to share and discuss their potential/ongoing research with other participants. Our survey results also showed that more than 80% of the participants have even found an opportunity of research collaboration. The respondents gave an average score of 4.48 out of 5 for the sharing session, indicating its success.

Workshop: Quantitative Trading and Machine Learning
The workshop was held on 8 March 2017 and attracted 36 participants. It (1) covered key elements of quantitative trading, from trading technology to research platform, from a high-frequency trading perspective, (2) answered questions on career development in quantitative trading, and (3) introduced quantitative trading and application of machine learning in quantitative trading. In general, all our participants enjoyed the conference. They were satisfied with the performance of both guest speakers, who received an average rating of 4.92 and 4.85 out of 5, respectively. Almost all the respondents strongly agreed that they the seminar has helped them to expand their knowledge about machine learning. As for the organization of the whole event, the respondents gave an average score of 4.46, meaning that the event was well-organized and easy to follow. The length of the seminar was also deemed appropriate. Overall, all the respondents agreed that the seminar met their expectations and they were willing to give an average score of 4.85 out of 5 for the whole experience.

Workshop: Insights on Deep Learning (9 January 2018)
There were 74 attendees at Insights on Deep Learning and the response rate of the survey for this event was 81%. In general, the attendees were satisfied with this workshop. On a scale of 1 to 5 with 5 being the highest and 1 the lowest, our attendees rated this conference with an average score of 4.57. They also found the guest speakers to be knowledgeable on the topics. More than half participants gave a 5 for their presentations. After the workshop, over 90% of the respondents agreed that they have gained a better understanding on the topics after the conference. Some commented that the conference was valuable and had learnt a lot from it. Some even looked forward to joining similar sessions in the future and hoped that we can extend the topics discussed

Workshops: (1) Legal Analytics and (2) Translation Technology (26 January 2019)
There were a total of 25 people who attended Workshop on Legal Analytics and Translation Technology, in which 52 % of them had responded to the survey. The survey results are generally favourable with our respondents rating the workshop an average of 4.6 out of 5. Our respondents on average gave a 4.3 for both the speaker and the overall content of this workshop. Some even complimented that the talk had exceeded their expectations and even hoped that the duration of the talk can be longer so that the speakers can give a more in-depth explanation about the deep learning applications discussed.

Workshop: Distributed Deep Learning
On 14 March 2019, DLC invited Professor Xiaowen Chu (Department of Computer

Science, HKBU) to be the speaker of our workshop on distributed deep learning. In his presentation titled "Computing and Communication Challenges in Deep Learning", Prof. Chu covered topics such as fundamental computing tasks in deep learning, current challenges in parallel processors, the design of distributed deep learning systems ,and recent works that try to alleviate the communication bottleneck within such systems. The participants were very satisfied with the speaker and the content of the presentation. They strongly agreed that the event was well-organized and the logistics (length, location time) were appropriate.

Workshop: Financial Translation with Deep Learning
On 26 April 2019, Dr Sai-cheong Siu gave a presentation on "New Technology for Financial Translators", which discussed the development of an automatic translation platform for listing documents using state-of-the-art natural language processing methods and demonstrated how the translator-oriented features of the system could facilitate human-computer collaboration in the process of translation.

Conference: Artificial Intelligence for the 2020s: Deep Learning and Beyond
On 21 September, DLC held its biggest event of the year: a conference titled "Artificial Intelligence for the 2020s: Deep Learning and Beyond". As part of our efforts to promote deep learning technology to the community, DLC aims to host one conference each year to provide a platform for specialists and industrial practitioners to share with each other the latest developments of AI. This year, DLC had invited eight speakers for the conference, in which they covered a range of topics from AI with finance and marketing to AI and law, and from AI algorithms to AI education. The conference lasted for a whole day and was a success. There were over a hundred of participants who registered for the event, including students, researchers, and industrial practitioners. Most of the participants found the talks interesting and thought-provoking.

Other Talks and Workshops on Deep Learning or Artificial Intelligence
Members of DLC gave external talks on Deep Learning to promote its use and application. For instance, external talks were given at IVE at Chai Wan, Tuen Mun and Lee Wai Lee (24 January 2017, 14 March 2017 and 6 April 2017), Science Museum (9 April 2017), Chu Hai College (21 April 2017), HKPC (19-20 June 2017), Cyberport (24 June 2017), InnoTech Expo (29 September 2017), Hong Kong Observatory (1 March 2019), France Macau Chamber of Commerce (29 May 2019), and a conference on Customer Experience (19 September 2019).

In addition, a deep learning talk titled "Harness the Power of Neural Networks for AI: Applications of Deep Learning" was given by the Team Leader at the event "'近距實戰: 教您如何快速打造整合 AI 工作平台'體驗營" co-organised by Digital China, IBM and IT Channel on 26 November 2018. The talk offered an overview of the following: (1) concepts of AI, machine learning and deep learning, (2) key features of deep learning, (3) applications of deep learning, and (4) ways to develop deep learning applications. We also gave talks on the application of Deep Learning to English writing correction at the eClassDay event on 24 March 2018 and 23 March 2019 and co-organised 3 workshops with the Department of Mathematics and Statistics from September to November 2018: (1) Workshop on Machine Learning and Big Data Analytics, (2) Workshop on Risk Analytics, and (3) Workshop on Social Media Analytics.

Overall summary
In general, the DLC has mainly received positive feedback from the participants. According to our survey reports of the main DLC workshops, generally speaking, our

guest speakers have received a score of more than 4 out 5 from our participants, which reflects how much our participants enjoyed the content our guest speakers brought. The talks themselves were well-organised and intriguing as well. Our survey respondents commented that talks had broadened their horizons on deep learning applications, thanks to the well-structured presentations. Many hoped that we will continue to host such seminars or workshops in the future to cover more topics and give more in-depth discussions on deep learning. Some even suggested that we should host a workshop on hands-on implementation of deep learning applications. Apart from the content, our seminars have also provided a platform for researchers of the same field to seek and discuss research collaborations. To sum up, the quality of the seminars and workshops has met our participants' expectations. The DLC will continue to host high-quality seminars and workshops in the future.

Please refer to **Appendix 2** for more information about the activities.

(ii)   Please provide reports on asset purchase such as acquisition of research facilities, communal equipment, software licence, dataset and / or status of infrastructure / physical research structure building such as research centre, research supporting unit (if applicable).
(Please provide supporting documents and / or photos, and provide the utilization rate.)

A tender was called for the equipment listed below on March 27, 2017, with closing date of 21 April 2017. Three companies replied and the lowest tender bid was selected and approved by the Tender Board on 9 May 2017. See **Appendix 3A** for the Tender Board papers for meeting on 9 May 2017, **Appendix 3B** for the purchase order, and **Appendix 3C** for photos and system configuration. The equipment was installed in June 2017 and use of the equipment started immediately.

Item 1 - 1 Set 10Gb Network Switches (for iSCSI connection);
Item 2 - 1 Set 40Gb Network Switches (for host-to-host high speed connection);
Item 3 - 2 Sets Rack-mounted Servers (for high performance computing);
Item 4 - 1 Set Rack-mounted iSCSI Storage; and
Item 5 - Rack-mounted KVM.

Subsequently, the following were purchased:
- A high-performance MacBookPro was purchased in June 2017.
- Additional GPUs were purchased in October 2017 (quotation in **Appendix 3D**).
- The licence for MATLAB software was procured and installed in October 2017.
- Additional memory of 16GB for 5 PCs was procured in December 2017.

In view of the growing number of deep learning projects (increased from 1 to 6 since 2017) and surging demand for the training of multi-layer neural networks for the projects, it is necessary to expand the existing deep learning infrastructure to provide better support for current and new machine learning projects.

A tender was called for the items listed below on 11 January 2019, with closing date of 31 January 2019. Two companies replied and the lowest compliant offer was selected and approved by the Tender Board on 22 February 2019. See **Appendix 3E** for the Tender Board papers for meeting on 22 February 2019 and **Appendix 3F** for the

purchase order.

Item 1 - 2 Sets Rack-mounted Servers with 768 Gb ECC RAM;
Item 2 - 1 Set of Acronis Backup 12.5 Standard Server Software for two physical hosts;
Item 3 - Implementation Services; and
Item 4 - 2 Sets Dell PowerEdge 4140 Parts - (RAID 1) with two M.2 Sticks 240G.

The following items were also purchased: (1) a new license for MATLAB software was procured and installed in December 2018; (2) 4 sets of 15-inch Microsoft Surface Book 2 with accessories were purchased in December 2018; and (3) a server for the demonstration of deep learning projects was purchased in 2019.

The DLC staff have been working full-time on the deep learning research projects, which require extensive computational experiments on data to be done (sometimes overnight) on the purchased equipment. The utilization rate is at least 70-80%.

(iii)   Please provide reports on research activities carried out (if applicable).

The following machine learning projects were carried out:

Machine Translation with Deep Learning Methods – with the School of Translation
Deep Learning has been proven to lead to good outcomes for machine translation, as demonstrated by, for example, Google Translate. When the translation is confined to documents for a specific domain (or fixed context), we believe the translation outcome could be even better and practically used, especially with the support of School of Translation, which will provide the project with relevant expertise and advice.

This project involves English-to-Chinese translation of initial public offering (IPO) prospectuses and similar offering documents (hereafter called "IPO Documents") submitted to the Hong Kong Stock Exchange (HKEX). IPO Documents are generally drafted in English by professionals (lawyers and accountants) in Hong Kong. However, the HKEX requires these documents to be provided in both English and Chinese. Hence, financial printers, which print the IPO Documents, often undertake the responsibility of the translation and it constitutes a heavy part of their revenues and costs. By developing a machine translation system, we hope we can help companies cut costs and increase efficiency when it comes to translating IPO documents. An MOU has already been signed with Alpha Financial Press Limited to carry on this project.

A.I. Smart Retail Project – with the School of Business
This project aims to apply deep learning technology to retail inventory management. Using the latest object detection and classification algorithms, we can draw bounding boxes surrounding the retail products shown in an image. The sets of bounding boxes represent different products that are also training materials. The technology can help retailers to recognise stock keeping units, price compliance and share of shelf, which in turn assists them in making marketing decisions and improving their sales. Similar applications have been developed by other deep learning models such as faster R-CNN, Mask R C-NN, and YOLO. DLC is now seeking for any partnership for this project.

Hong Kong Student's English Writing Correction – with the School of Humanities and Social Science
In collaboration with the English department at HSUHK, this project aims to develop a

deep learning-based automatic English writing checker for Hong Kong students. At present, traditional grammar checkers can only check simple grammatical errors. However, they fail to detect semantic flaws and are not tailored for Hong Kong students. Therefore, DLC aims to develop a deep learning-based checker which includes a unique Hong Kong students' error corpus for training. At the initial stage of the project, the team had collected essays form HSUHK students and created a web-based interface for the HSUHK teachers to annotate different writing errors on them. We then trained the model using the students' compositions and their respective annotations. The results were satisfactory: our model on average can detect more grammatical errors than a popular grammar checking tool on the market. More importantly, our system is capable of identifying and correcting complex errors that Grammarly cannot, especially when it comes to redundancy and word choice. The project has received support from eClass. After submitting the proposal, DLC was invited to an interview with the ITF board in September 2019.

Intelligent Configurations (iCON) Design – with the School of Decision Sciences
Online product configurations are prevailing tools the in e-commerce industry. Yet current online configurations require customers to specify the choices of each product attribute, which poses a great challenge for customers with no background knowledge. Hence, this project aims to develop a new online product configuration approach which enables customers to find a product online just by specifying their functional requirements, instead of the detailed design parameters. For example, when users input the keywords like "a large screen size laptop", our approach could map the associated features and give high quality recommendations. We are developing auto tools to collect online user reviews as corpus and training deep neural networks to predict and display the items a user would like to purchase with top accuracy.

Swarm Intelligence (SI) – with the School of Decision Sciences
Swarm intelligence (SI) is the collective behaviour of decentralised and self-organised swarm robots. The swarm robots could be unmanned vehicles (driverless cars), aerial vehicles (UAVs), autonomous underwater vehicles/ underwater vehicles (AUVs/UUVs) and ships. Each robot is usually battery powered and equipped with a wireless transceiver to exchange information with its neighbours. These robots can carry a variety of electromechanical sensors to explore and interpret their environments. Applications of these swarms include surveillance, search and rescue, mining, agricultural foraging, autonomous military units and distributed sensing in micromachinery or human bodies.

Deep Learning Applications on Weather – with the School of Decision Sciences
"Deep Learning Applications on Weather" focused on the application of different deep learning architectures on weather applications. Through reviewing and conducting research, we aimed to develop new applications for weather analysis, forecast, and communication using deep learning. The project explored the possibility of applying deep learning to image captioning of weather-related images, as well as to object recognition for cloud type identification.

Later the Centre decided to apply deep learning to two tasks related to weather services: caption generation and object recognition for weather-related images. Weather services, such as weather forecasting and education, are highly useful to residents. Although the weather changes from time to time, weather services remain routine and thus have a great potential in automation and implementing deep Learning to mimic and learn human practices and interpretations. For caption generation, the team first applied deep learning to rainfall maps. We used a batch of the simulated rainfall maps to perform

preliminary training and testing of CNN and RNN. As a result, the team has generated 200,000 simulated rainfall maps. We also tested rule-based algorithms for generating captions and preliminary neural networks. As for object recognition, we hope to apply it to cloud genera identification, in which we have already collected over 200,000 photos from Hong Kong Observatory's website for future training.

Internal Research Support
Apart from our own projects, DLC also supported research projects from various departments at HSUHK by providing software and other equipment. For example, we provided MATLAB for the project "Machine Learning for Evaluating Carbon Emission: Evidence from China", which investigates the issue of carbon emission of China through machine learning. DLC also collaborated with the Department of Computing for one of their student's FYP. The project is concerned with the aforementioned "Smart Retail by Deep Learning on Computer Vision". DLC members have been guiding the student through various tasks including data collection, cleaning, and annotation. He came across the skills in data collection, image processing, database building, as well as deep learning and AI algorithms in this project.

See **Appendix 4** for more information about the DLC projects.

6.2 Please describe where and how the IDS Research Infrastructure Grant project assisted in building up the research capacity of the institution in its strategic areas (e.g. has the IDS Research Infrastructure Grant project facilitated the academics in formulating their research proposals under the Faculty Development Scheme, etc.).

This project facilitated the academics in formulating the following research proposals:

Machine Translation of IPO prospectuses: An ITF proposal was developed in 2018 together with the School of Translation.

A.I. Smart Retail Project: An ITF proposal was developed in 2019 together with the School of Humanities and Social Sciences.

Hong Kong Student's English Writing Correction: An ITF proposal was developed in 2019 together with the School of Business.

Deep Learning Applications on Weather – An ITF proposal was developed in 2019 together with the School of Decision Sciences

Two more FDS proposals on swarm robots and mobile apps privacy developed by members of the Department of Computing were developed and submitted in 2020.

6.3 If the project has not met its original objectives, why?

The project has met its original objectives.

6.4 (a) Please provide details e.g., title, authorship, publication dates, etc. and attach an abstract of each publication reported. Please place asterisks on publications involving inter-institutional collaborations.

The publications are as follows:

CHEUNG, Lap Pong; YANG, Haiqin. Heterogeneous Features Integration in Deep Knowledge Tracing. In: *International Conference on Neural Information Processing ICONIP (2)*. October 14-18, 2017: 653-662. (Best student paper awards finalist.)

YANG, Jie; LEUNG, H.C.M.; YIU, S.M; CHIN, Francis YL. Mixed Membership Sparse Gaussian Conditional Random Fields. In: *Conference on Advanced Data Mining and Applications ADMA*. November 5-6, 2017: 287-302. (Best Paper Runner-up Award.)*

YANG, Haiqin; CHEUNG, Lap Pong. Implicit Heterogeneous Features Embedding in Deep Knowledge Tracing. In: *Cognitive Computation*, 2018, 10.1: 3-14.

LUO, Linkai; YANG, Haiqin; CHIN, Francis YL. EmotionX-DLC: Self-Attentive BiLSTM for Detecting Sequential Emotions in Dialogue. In: *Proceedings of the Sixth International Workshop on Natural Language Processing for Social Media*, 2018: 32-36.

LUO, Linkai; YANG, Haiqin; SIU, Sai Cheong; CHIN, Francis YL. Neural Machine Translation for Financial Listing Documents. In: *International Conference on Neural Information Processing*. Springer, Cham, 2018. p. 232-243.

YANG, Haiqin; LUO, Linkai; CHEUNG, Lap Pong; LING, David; CHIN, Francis YL. Deep Learning and Its Applications to Natural Language Processing. In: *Deep Learning: Fundamentals, Theory and Applications*. Springer, Cham, 2019. p. 89-109.

WANG, Yue; ZHAO, Wenlong; WAN, Wayne Xinwei. Needs-Based Product Configurator Design for Mass Customization Using Hierarchical Attention Network. In: *IEEE Transactions on Automation Science and Engineering*. DOI: 10.1109/TASE.2019.2957136, 2020.*

Please refer to **Appendix 5** for abstracts.

(b) RGC funding should have been acknowledged in all activity(ies) / publication(s) / conference(s) papers listed in (a) above. If no acknowledgement has been made in any of the event / publication / paper, please indicate and provide explanations.

N/A

6.5 Research staff trained

(Please provide names and capacities of research staff trained and elaborate on what training has been provided.)

> Please see **Appendix 6**.

6.6 Specific products
(e.g. patents, software or netware, instruments or equipment, infrastructure developed)

> The following software / prototypes were built:
>
> For the English writing project, the DLC built a marking/self-correction prototype for teachers/students to identify Hong Kong English in writings using deep artificial neural networks.
>
> For the project "Deep Learning Applications on Weather", in a meeting with the Hong Kong Observatory (HKO) in 2018, it was suggested that captions for rainfall maps could be generated with deep learning. With HKO's rainfall map data, we built a prototype generating captions for rainfall maps input.

6.7 Other education activities and / or training and development

> An AI Portal was built for the dissemination of useful resources for the teaching and learning of artificial intelligence, including machine learning and deep learning (https://sites.google.com/hsu.edu.hk/ai-portal/home). The website consists of five sections: (1) cheat sheets, providing links to useful summaries of key concepts in deep learning, including linear algebra, calculus, supervised learning, unsupervised learning, neural network architectures, and programming; (2) courses, offering links to free web-based courses on deep learning, including tutorials on Tensorflow, python, and data science; (3) datasets, a collection of websites offering open datasets applicable to the training of deep learning models; (4) news, offering links to websites sharing the latest news about artificial intelligence; and (5) tools, providing access to a list of free deep learning tools, including Colab (providing jupyter notebooks and free GPU time), Keras, PyTorch, Tensorflow and others. We promoted the website in a talk on the teaching and learning of Deep Learning, which was delivered by the DLC Director after the Deep Learning conference on 22 September 2019.
>
> We also promoted Deep Learning among secondary school students. For example, in August 2019, DLC was invited to set up a booth at an AI event for secondary school students organized by the Department of Computing, HSUHK to share with them our projects such as the English writing checker.

6.8 Please highlight any deliverables indicated in the project implementation timetable endorsed by RGC, which have not been covered or achieved as per sections 6.1 to 6.7 above, and explain / elaborate.

> All covered or achieved.

6.9   Please elaborate the role of the managing team in coordinating and managing the project.

Members of the DLC met regularly to monitor the progress of different research projects, and meeting notes were prepared for the meetings. In addition, an Advisory Committee was formed with internal and external members to advise on (1) how to promote the Centre and encourage more projects, (2) how to solve the manpower problem, (3) possible industry collaboration and supports, and (4) strategic direction and next steps. The role and responsibility of DLC team members should be the same as the objectives of the DLC, including supporting and promoting research using deep learning technology. See **Appendix 7** for minutes of the meetings.

7.   Awards And Recognition

7.1   Have any research grants been awarded that are **<u>directly</u>** attributable to the results obtained on this IDS Research Infrastructure Grant project? *(Please provide details)*

The project on machine translation of IPO prospectuses (see above) led by the School of Translation was supported by the Innovation and Technology Support Programme of the Innovation and Technology Commission, which offered a grant of HK$1,400,000 for the development of a neural machine translation prototype. The project was completed on time in July 2019.

7.2   Other awards and recognitions as a result of this IDS Research Infrastructure Grant project *(Please specify)*

One of our workshops "The Workshop on Legal Analytics" (see above) was covered by an online article (https://goo.gl/x418At) published in Hong Kong Lawyer 《香港律師》, the official journal of the Law Society of Hong Kong.

8.   Other Impacts

8.1   What are the current and expected impacts of the project in terms of its contribution to the local and regional economic and societal well-being? *(e.g., technology transfer, collaboration with external organizations, etc.)*

In line with the mission and strategy plan of the HSUHK, the DLC is committed to making an impact with technology transfer and more collaboration with external organisations. For example, the machine Translation project contributed to the preparation of bilingual listing documents for the transparency of the stock market in Hong Kong. The English writing project, which entailed AI-driven correction of English writings and identification of Hong Kong English, helped contribute to the enhancement of the English writing proficiency of local students for long-term development of Hong

Kong as an Asia's world city. The smart retail project helped identify on-shelf products and tracking the movement of customers in shops, and the findings can be very useful in the retail industry for stock management, promotion planning, consumer behaviour analysis, and even the establishment of checkout-free stores.

We explored collaboration possibilities with external parties, including Hong Kong Observatory, Alpha Financial Press, Max Choice, Hung Fok Tong, Saint's Alp House, and eClass. We also had discussion with other I&T enterprises (or organisations) such as Koding Kingdom, STEM Academy and DataTech, so as to further increase the visibility of the Centre and to identify more collaboration and funding opportunities for the long-term development of the DLC.

8.2   Others *(Please specify)*

N/A

9.   Statistics on Research Outputs

	Peer-reviewed Journal Publications	Conference Papers	Scholarly Books, Monographs and Chapters	Patents Awarded	Other Research Outputs (please specify)	
No. of outputs arising directly from this project	2	3	2	0	Type	No.

10.   Sustainability of The IDS Research Infrastructure Grant

10.1 Whether there are new ideas evolved **directly** from the project?

The success of Deep Learning in various applications has led to the more ambitious goal of creating systems that learn, reason, and interact with humans as partners and collaborators. Cognitive computing, which involves the integration of technologies in machine learning, reasoning, natural language processing, pattern recognition, human-computer interaction, and supporting technologies in robotics, cloud computing, and security and privacy, is expected to have many applications and great impact to our daily life.

In view of this development trend of Deep Learning, we propose to expand the scope of DLC to include Cognitive Computing. The new vision of the Centre is to be recognized in the region as a research centre of high-quality research in Deep Learning and Cognitive Computing. The new objectives are (1) to undertake high quality and relevant research in Deep Learning and Cognitive Computing, (2) to collaborate with external parties from the industry, government and academia on Deep learning and Cognitive Computing research, (3) to foster collaboration among departments/schools in

Deep Learning and Cognitive Computing research, and (4) to disseminate the experience and results in the application of Deep Learning and Cognitive Computing

To achieve its objectives, the Centre will organise a wide range of new activities. We will facilitate and support its members to carry out fundamental and applied research in not only Deep Learning, but also Cognitive Computing. Members of the Centre will also carry out academic research and publish their results in academic journals and conferences.

10.2 Whether there are new projects evolved **<u>directly</u>** from the project?

In the third year of operation, DLC members started exploring new projects for the long-term, sustainable development of the Centre after the end of IDS project. Here are a few examples:

Site Monitoring: This project aims to provide a cost-effective solution for site inspections through real-time monitoring sensors and the application of big data and AI. For construction sites, maintaining site safety is of utmost importance. However, as safety officers are not on site 24/7, they may fail to monitor whether workers are always strictly following the safety requirements. Another safety concern for construction sites is that accidents / near-missed cases often cannot be detected immediately, which can lead to life-threatening situations. At present, DLC is researching methods to detect whether workers are wearing safety helmets at construction sites. Members have already built a preliminary model for helmet detection, which can detect human pose, the presence of helmets, as well as the colour of helmets. In the future, we will continue to work on danger zone approaching identification and detection of accidents.

Caterpillar Fungus or Chinese Herbs Recognition by Deep Learning: Caterpillar fungus is a rare and valuable Chinese medicine. They are also extremely fragile, meaning that they must be counted by hand. As a result, Chine medicine dealers have to spend extra costs in hiring manpower for counting the herb. The process is slow and prone to errors. Therefore, we are looking for a deep learning solution that can raise both efficiency and accuracy in counting caterpillar fungus. Recently, we have undergone some data training using over 200 toy caterpillar fungus photos. We have adopted faster R-CNN to create class and bounding boxes for the fungus, which are all annotated afterwards.

AI for L2 Learners: The project aims to develop a web-based automatic system for English L2 learners to correct their pronunciations. One difficulty Hong Kong ESL learners often face is pronunciation. On top of that, they lack the resources that can provide instant feedback and correction methods. With our system, however, students can practise their English pronunciation at anytime and anyplace. When they speak through the system, it recognizes their voices and then compares their pronunciation with the standard version. Using AI technology, the system will then analyse their pronunciations and provide instant feedback on their performance, as well as highlighting places that need to be improved. This is helpful for ESL learners to track their learning progress and specific error patterns, hence improving their speaking skills.

In addition, members in the Department of Computing have identified various new projects for the Centre, including intelligent tutoring systems, swarm robotics, Deep Learning on cloud, cryptocurrency price movement prediction, enhancement of mobile

apps privacy with Deep Learning, multi-agent-based simulation of social norm, and investment market sentiment.

10.3 Whether there are new collaborations developed **directly** from the project?

Our researchers have been in discussion with industrial partners with a view to exploring various research opportunities with companies or organisations in different sectors for new collaborations. It is expected that some external funding will be available in the coming years.

10.4 Please give details on how much money and from which sources has been obtained for the specific purpose of continuing the work started under this IDS Research Infrastructure Grant project.

Please see **Appendix 8**.

11. Public Access Of Completion Report
(Please specify the information, if any, that cannot be provided for public access and give the reasons.)

Information that Cannot Be Provided for Public Access	Reasons
Appendices	The appendices contain personal/restricted/sensitive information and internal documents.

RGC Ref. No.:

UGC/IDS14/16

(please insert ref. above)

INSTITUTIONAL DEVELOPMENT SCHEME (IDS)
RESEARCH INFRASTRUCTURE GRANT

Summary of Completion Report
(Please list all the stages since project inception)

Project Title: Establishment of a Deep Learning Research & Application Centre (DLC)

Stage Completed	Period		Milestones	
	(Month / Year) to (Month / Year)		**Deliverables to be Achieved[2]** **(Please summarize in three bullet points where details should be left to the report proper)**	**% of Each Deliverable Achieved[3]**
1	01/01/2017 to 31/12/2017		1. (a) Setting up the Centre and hiring staff (b) Acquiring hardware/software 2. Organising two tutorials and one workshop 3. Selecting and initiating collaborative projects	1. (a) 100% (b) 35% 2. 100% 3. 100%
2	01/01/2018 to 31/12/2018		1. Promotion of Deep Learning and one workshop 2. Conduct and validate the models of the research projects 3. Acquisition of hardware and software (carried over from the first year of operation)	1. 100% 2. 100% 3. 75%
3	01/01/2019 to 31/12/2019		1. Fine-tuning of the models of the research projects and dissemination of results 2. Organisation of one conference 3. Acquisition of hardware and software (carried over from the first year of operation)	1. 100% 2. 100% 3. 100%

Stage Completed	Period		Milestones	
	(Month / Year) to (Month / Year)		**Deliverables to be Achieved[2]** (Please summarize in <u>three</u> bullet points where details should be left to the report proper)	**% of Each Deliverable Achieved[3]**
	Total to-date:			

Note: [1] Justifications for significant under-spending or over-spending (≥ ±10%) should be given in **section 5.1** of the completion report.

  [2] The key milestones to be achieved by the project within the respective stage as indicated in the approved implementation timetable.

  [3] Justifications for significant slower rate of progress compared with the approved implementation timetable should be provided in detail in **section 4** of the completion report.