RGC Ref. No.:
UGC/FDS13(14)/E02/14
(please insert ref. above)

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

FACULTY DEVELOPMENT SCHEME (FDS)

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.*

Part A: The Project and Investigator(s)

1. Project Title

Accelerating Nonrigid Image Registration using local information measure and GPU implementation

2. Investigator(s) And Academic Department(s) / Unit(s) Involved

Research Team	Name / Post	Unit / Department / Institution
Principal Investigator	CHEUNG Kwok Wai, Associate Professor	School of Communication, Hang Seng Management College
Co-Investigator(s)		
Others		

3. Project Duration

	Original	Revised	Date of RGC / Institution Approval *(must be quoted)*
Project Start Date	1 Jan 2015		
Project Completion Date	31 Dec 2016	30 Jun 2017	17 Jun 2016
Duration *(in month)*	24	30	17 Jun 2016
Deadline for Submission of Completion Report	31 Dec 2017	30 Jun 2018	17 Jun 2016

Part B: The Final Report

5. Project Objectives

5.1 Objectives as per original application

1. To develop local mismatch measures based on local mutual information for image registration.
2. To develop new nonrigid image registration algorithm based on local mismatch measure methods that can significantly reduce the computation requirement and facilitate the parallelization of the algorithm.
3. To implement nonrigid registration algorithm on system with Nvidia GPU processor and general-purpose multicore architectures to achieve high efficiency

5.2 Revised objectives

Date of approval from the RGC: _____

Reasons for the change: _____

1.

2.

3. ....

5.3 Realisation of the objectives
(Maximum 1 page; please state how and to what extent the project objectives have been achieved; give reasons for under-achievements and outline attempts to overcome problems, if any)

The first two project objectives have been achieved. As the CUDA implementation on GPU involving time consuming low-level programming work, it was difficult to recruit a full-time research assistant with relevant programming skills to assist the implementation. Thus, the last project objective is only partially completed. The idea of parallel computation with CUDA is that a computation task can be decomposed into several independent subtasks, which can be executed simultaneously by the GPU threads. Currently the algorithm is implemented in C++ programming language. To take advantage of parallel computation, entire algorithm does not need to be written in CUDA. Only the most computationally intensive portions of the algorithm are to be implemented as CUDA kernel, i.e. the function executed by GPU threads, so that the computation can be offloaded to GPU to gain further speed improvement. With the help of a part-time research assistant, several tasks, particularly those involved in similarity measure, are already identified and partially implemented as CUDA kernels. It is expected to complete the implementation during this summer by the PI.

5.4 Summary of objectives addressed to date

Objectives *(as per 5.1/5.2 above)*	**Addressed** *(please tick)*	**Percentage Achieved** *(please estimate)*

1. To develop local mismatch measures based on local mutual information for image registration.	√	100%
2. To develop new nonrigid image registration algorithm based on local mismatch measure methods that can significantly reduce the computation requirement and facilitate the parallelization of the algorithm.	√	100%
3. To implement nonrigid registration algorithm on system with Nvidia GPU processor and general-purpose multicore architectures to achieve high efficiency	√	60%

6. Research Outcome

6.1 Major findings and research outcome
(Maximum 1 page; please make reference to Part C where necessary)

A fast adaptive bases non-rigid image registration with local optimization method is developed to speed up the free form deformation with radical basis functions. The algorithm applies matched areas identification in the initialization process and adaptive support size for basis function in the misregistration region identification process. Higher grid point density for local optimization is used in the identified misregistration regions. The registration speed can be significantly increased while maintaining the registration accuracy. As listed in Part C, the work was reported in a conference paper and a peer-reviewed journal paper submitted to Journal of Imaging Science and Technology.

6.2 Potential for further development of the research and the proposed course of action *(Maximum half a page)*

The algorithm can be further improved by exploring the parallel implementation using CUDA or OpenCL.

7. Layman's Summary

(Describe in layman's language the nature, significance and value of the research project, in no more than 200 words)

In medical image analysis, registration is a common preprocessing step for many planning, navigation, data-fusion and visualization tasks, which require the fusion of two images of similar or different modalities. Image registration aligns two images such that corresponding points can be related, for example to combine information provided by different image acquisition devices or monitor disease progression over time. For this purpose, one image is deformed to match the other one. Rigid registration applies affine transformation to one of the images to achieve an alignment. Satisfactory result can be achieved only in some special cases in which the anatomical structures of images are rigid. In general, nonrigid registration using more complex nonrigid transformation models are required. A major problem with nonrigid registration methods is the high computational cost with registration times in the order of hours for typical 3D images. This project developed techniques for improving the efficiency of nonrigid registration to speed up the process.

Part C: Research Output

8. Peer-Reviewed Journal Publication(s) Arising Directly From This Research Project

(Please attach a copy of the publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.)

The Latest Status of Publications				**Author(s)** *(denote the corresponding author with an asterisk*)*	**Title and Journal / Book** *(with the volume, pages and other necessary publishing details specified)*	**Submitted to RGC** *(indicate the year ending of the relevant progress report)*	**Attached to this Report** *(Yes or No)*	**Acknowledged the Support of RGC** *(Yes or No)*	**Accessible from the institutional repository** *(Yes or No)*
Year of Publication	**Year of Acceptance** *(For paper accepted but not yet published)*	**Under Review**	**Under Preparation** *(optional)*						
	2018			**K. W. Cheung*, Y. T. Siu, T. W. Shen**	**"Fast Adaptive Bases Algorithm for Non-rigid Image Registration", *Journal of Imaging Science and Technology***	**No**	**Yes**	**Yes**	**Yes**

9. Recognized International Conference(s) In Which Paper(s) Related To This Research Project Was / Were Delivered

(Please attach a copy of each conference abstract)

Month / Year / Place	**Title**	**Conference Name**	**Submitted to RGC** *(indicate the year ending of the relevant progress report)*	**Attached to this Report** *(Yes or No)*	**Acknowledged the Support of RGC** *(Yes or No)*	**Accessible from the institutional repository** *(Yes or No)*
May / 2016 / Montreal Canada	Improved Local Optimization for the Adaptive Bases Non-Rigid Image Registration	IEEE Int'l Symposium on Circuits & Systems 2016	2015	Yes	Yes	Yes

10. Whether Research Experience And New Knowledge Has Been Transferred / Has Contributed To Teaching And Learning

(Please elaborate)

Final year project students under the supervision of the PI could gain research-related experience by working on image registration project.

11. Student(s) Trained

(Please attach a copy of the title page of the thesis)

Name	Degree Registered for	Date of Registration	Date of Thesis Submission / Graduation
NA			

12. Other Impact

(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, teaching enhancement, etc.)

NA

13. 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
NA	

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FACULTY DEVELOPMENT SCHEME (FDS)

Completion Report - Attachment
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RGC Ref. No.:	UGC/FDS13(14)/E02/14
Principal Investigator:	CHEUNG Kwok Wai
Project Title:	Accelerating Nonrigid Image Registration using local information measure and GPU implementation

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 research project [or conference]	1	1			