RGC Ref. No.:
UGC/FDS14/E01/17
(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

Self-adaptive Collective Motion of Swarm Robots

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

Research Team	Name / Post	Unit / Department / Institution
Principal Investigator	Dr Hai Liu / Associate Professor	Computing/HSUHK
Co-Investigator(s)	Prof Yiu-Wing Leung / Professor	Computer Science/HKBU
Co-Investigator(s)	Prof Xiaowen Chu / Professor	Computer Science/HKBU
Others		

3. Project Duration

	Original	Revised	Date of RGC / Institution Approval *(must be quoted)*
Project Start Date	1/1/2018		
Project Completion Date	30/6/2020	31/12/2020	2/12/2019
Duration *(in month)*	30	36	2/12/2019

Deadline for Submission of Completion Report	30/6/2021	31/12/2021	2/12/2019

Part B: The Final Report

5. Project Objectives

5.1 Objectives as per original application

1. To design self-adaptive collective motion algorithm for swarm robots with no obstacles and no leader.
2. To design self-adaptive collective motion algorithm for swarm robots with no obstacles and a leader.
3. To design self-adaptive collective motion algorithm for swarm robots with obstacles (with and without a leader).

5.2 Revised objectives

Date of approval from the RGC: N/A

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)

1. To design self-adaptive collective motion algorithm for swarm robots with no obstacles and no leader.
Objective 1 has been fully achieved.
When there is no obstacles and no leader, we have designed a collective motion algorithm that move robots from the source to the destination.

2. To design self-adaptive collective motion algorithm for swarm robots with no obstacles and a leader.
Objective 2 has been fully achieved.
When there is no obstacles and a leader, we have designed a collective motion algorithm that move robots from the source to the destination.

3. To design self-adaptive collective motion algorithm for swarm robots with obstacles (with and without a leader).
Objective 3 has been partially achieved.
When there are obstacles and a leader, we have designed a collective motion algorithm that move robots from the source to the destination.
When there are obstacles and no leader, we have not identified an effective collective motion algorithm due to the complexity of the problem. Instead, we have applied the techniques developed in the study to a similar problem, where a collection of swarm robots (with no leader) search for targets.

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 design self-adaptive collective motion algorithm for swarm robots with no obstacles and no leader	✓	100%
2. To design self-adaptive collective motion algorithm for swarm robots with no obstacles and a leader	✓	100%
3. To design self-adaptive collective motion algorithm for swarm robots with obstacles (with and without a leader)	✓	60%^
4.		

^ It was elaborated in bold in paragraph 5.3 above.

Research Outcome

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

We have published one journal paper in IEEE Transactions on Automation Science and Engineering, and one conference paper in Qshine. We have done another research paper which will be submitted to IEEE Transactions on Mobile Computing.

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

We have extended the research of this project to a similar problem where a collection of swarm robots search for mobile/static targets in an area.

7. Layman's Summary

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

This research project is to design self-adaptive collective motion algorithms for swarm robots in 3D space. The proposed algorithms will enable swarm robots to move along a pre-planned path based on only one-hop neighbor information. The robots are requested to maintain topological connectivity and a desired neighboring distance during movement. The collective motion algorithms will enable the robots to be self-adaptive, dynamically adjust their movement parameters based on their environments and statuses and bypass obstacles of any shape and size without partitioning the swarm.

The significance of this research project lies in not only its scientific contribution to the literature (e.g., one journal publication and one conference publication), but also its potential value in many robotic applications where collective motion of robots is involved. In particular, the collective motion algorithms developed in this research can be directly applied in 1) robot-assisted search and rescue; 2) UAV/drone based photography and film production; and 3) reconnaissance using military robots.

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				H. Zhao, H. Liu, Y.-W. Leung, X. Chu	Self-Adaptive Collective Motion of Swarm Robots, IEEE Transactions on Automation Science and Engineering, 15(4), 1533-1545.	2018	No	Yes	Yes https://researchdb.hsu.edu.hk/view/publication/201800248
			✓	Hai Liu, Shujin Ye, Yu Tak Ma, Yue Wang	Motion Coordination of Swarm Robots for Mobile Target Searching, IEEE Transactions on Mobile Computing		Yes (Annex I)	Yes	No

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)*
2019 / Shenzhen / People's Republic of China	Search Planning and Analysis for Mobile Targets with Robots	The 15th EAI International Conference on Heterogeneous Networking for Quality, Reliability, Security and Robustness (Qshine 2019)		Yes (Annex II)	Yes	Yes https://researchdb.hsu.edu.hk/view/publication/2019 00303

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

(Please elaborate)

Yes, I have included research of this project as a case study in teaching COM2101 Computer Network for UG students in HSUHK.

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**
Nil			

12. Other Impact

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

Nil

13. 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	1 published 1 under preparation	1			Type	No.

14. 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
Nil	