Interim Evaluation Report for I&T Trial Project

Robots for Indoor Disinfection (Package "A10")

I&T Project No. : P-0101
I&T Wish No. : W-0241
I&T Solution No. : S-0393

E&M InnoPortal

EMSD

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Purpose of the Project and Target Deliverables

This project aims to develop a robot for indoor area disinfection, in order to maintain environmental hygiene and minimize cleaning staff's exposure to viruses and germs. The subject robot shall be able to perform both manual and automatic remote control for indoor disinfection tasks (e.g. spraying of disinfectants) such as in office environment, sports complex and quarantine areas.

Project Description

The disinfection robot tested in this project is known as Intelligent Sterilization Robot (ISR), which reportedly is the first Autonomous Mobile Robot (AMR) that has integrated both UV-C light and disinfectant vaporization nozzles for efficient disinfection. ISR also comes with two PM2.5 HEPA air filtration modules which are intended to prevent the spread of airborne bacteria.

Trial Site

The E&M InnoZone at headquarters of Electrical and Mechanical Services Department has been chosen as the primary trial site for this project.

Type of Equipment/ Installation/ Technology Adopted

Autonomous mobile robot with multiple disinfection features are adopted. The robot is designed to access areas autonomously and carry out disinfection at designated areas.

Trial Timeframe

The trial project would tentatively last for 6 months in various locations. An interim evaluation has been conducted in EMSD HQs from 17th to 27th April 2020.

Name and Background of I&T Solution Provider

Name: Time Medical Systems

Background: According to their website, Time Medical specializes in advanced medical imaging systems including MRI, DR and CT, as well as solutions for emerging global healthcare needs. It is also a tenant of The Hong Kong Science and Technology Parks Corporation (HKSTP).

Details of Implemented Trials

I. Methodology and Applicable Standards

A. Specification (data source: Time Medical Systems)

Attributes	Description
(i) Dimension	1.42 x 0.6 x 0.6m (idle) 1.9 x 0.6 x 0.6m (in operation)
(ii) Weight	90 Kg
(iii) Coverage	400 m^2 /h
(iv) Type of Cleaning / Filtration System	HEPA Filter, UV-C Light, Fine mist Disinfectant nebulizer (~ 5um, disinfecting chemical solution)
(v) Disinfectant spraying rate (if applicable)	0.0667 ml/ s
(vi) Maximum Speed	(full speed) ~ 1.5 m/s (normal) < 1.2 m/s
(vii) Others: (e.g. Maximum load or other item if necessary)	UV-C light with UV hazard (Class 3) which should not be activated when human is present. Safety precautions should be adhered to when operating with fine mist chemical.

(viii) Standards	• CE • GB 9706.1 2007 Medical electrical equipment safety • CMA Inspection • RoHS

B. Control and Design

Attributes	Findings
General	
(i) Structure	Generally intact. Slight vibration is observed in the disinfectant container during operation.
(ii) Surface finish	No noticeable gap or defect is observed.
Navigation	
(i) Navigation technology	3D Camera, LiDAR and IR sensors for home return
(ii) Navigation performance	Capable of autonomous patrol without technician intervention during trial. Positioning accuracy: No failure was observed in 5 nos. of "return to home" attempts.
(iii) Ability to move across levels	Not tested.
Mechanical Movement	
(i) Axis of movement	• Degree of Freedom robot spray head / UV light tubes • Degree of Freedom navigation (2D Plane)
(ii) Stability	• Slight vibration on uneven floor. • No noticeable noise during locomotion.
(iii) Obstacle detection and avoidance	• Sensors capable of detecting front side obstacles (180 degree view) • Capable of corner turning in passage with width at above 1 meter • Capable of obstacle avoidance. No crash incident during interim evaluation.

Attributes	Findings
(iv) Span of reach	• 1850mm when fully extended • disinfectant spray able to reach ceiling (approx. 3.0m)
(v) Irregular Floor Navigation	Not tested.
(vi) Operation duration (per charge)	3 hours operation per 2.5 hours charge
(vii) Disinfection features (from E&M perspective)	• According to solution provider's report, HEPA filter in the robot can remove at least 99.95% particles of 0.3um size. The pathogen in surrounding air can be removed and achieve disinfection purpose. • According to solution provider's report, UV-C (hazard Group 3) light can kill bacteria and viruses. • The disinfection nebulizer can generate fine mist spray of disinfectant. The extended spray head can spread disinfectant at ceiling level to clean areas that is difficult to reach. • The disinfection performance is subject to further verification.
Safety Features	
(i) E-stop button	E-stop is conspicuously located at the front of the robot and can be easily reached. The robot can be stopped immediately by the E-stop, or alternatively by the remote controlling tablet without approaching the robot.
(ii) Impact detection	Not tested
(iii) Alarm signals	• Yellow light is observed during disinfection. • Audible voice warning before disinfection and moving is observed

C. User experience

Attributes	Findings
(i) Network Connection	• Local WiFi access is required for communication and mapping. • The connection is stable during the test.
(ii) User Interface	• Generally user-friendly for mapping and navigation. • More user comments would be collected in subsequent site trials.
(iii) Tools for control	Web-based, Bluetooth controller and mobile device.
(iv) GUI design	• Generally user-friendly for mapping and navigation. The button of critical functions (start and stop) can be enlarged. • More user comments would be collected in subsequent site trials.
(v) Ease of Use	• Training is required for operation. • More user comments would be collected in subsequent site trials.
(vi) Maintenance Requirement	• HEPA Filter to be replaced every 3 months (subject to usage) • Automatic patrol requires an initial mapping process.

D. Others

Attributes	Findings
(i) Safety Consideration	• The system shall be operated by authorized and trained personnel. • The robot should only be used indoor and presence of human should be avoided when the UV-light is in operation. Use of disinfectant should be in accordance with manufacturer's recommendation. • According to International Commission on Non-Ionizing Radiation Protection (ICNIRP), UV-C light is harmful to human eyes and skin. For indoor workers exposed to artificial sources such as UVC-emitting lamps, safety precautions should be adhered such as engineering control (e.g. interlock), administrative control and provision of personal protective equipment. Individual workers should be made fully aware of the risks of excessive UV exposure.

II. Measurement and Verification Activity Details

E. Preliminary Functional Test Result

An initial test on mapping and autonomous navigation was performed at EMSD HQ as a trial site. The test covered office areas, corridors and lift lobby.

The robot was able to achieve the followings:

(a) Identify the best path and conduct disinfection procedure autonomously after mapping.

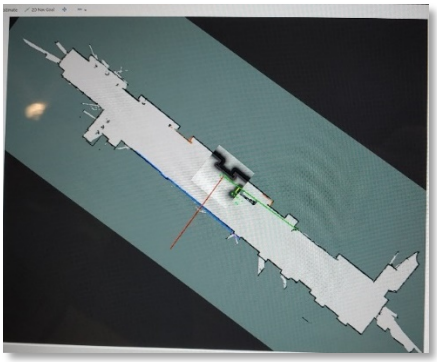
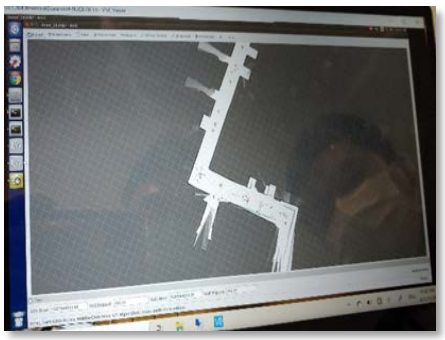
(b) Complete mapping in about 1 hour for an office area of approx. 400m^2.

(c) Navigate complex office environment and narrow corridors without touching other objects and moving persons.

(d) Revise its route to the destination if the path is blocked by objects.

The accuracy of the LiDAR and 3D camera navigation system was in general satisfactory for use in office environment, lift lobby and corridor.

F. Test Photos

Photographs	Descriptions
	1. The mapped layout of office area.
	2. The mapped layout of lift lobby.
	3. E&M InnoZone Corridor
	4. The mapped layout of E&M InnoZone Corridor.

Interim Review on Performance and Outcomes

The robot is able to map and perform UVC disinfection procedure autonomously. The following areas are proposed for improvement:

(a) In view of the use of UV-C light, a sensor or motion detection algorithm is proposed for detecting nearby human activity to reduce the risk of exposure to human.

(b) PPE shall be provided along with the system as a standard package.

(c) Software improvement that provides an enhanced AI capability to optimize mapping, navigation and disinfection time.

(d) HEPA filters may be enhanced by adding Nano disinfectant coating to kill the bacteria and virus through the air filtration module.

(e) Sufficient time of both visual and audible warning shall be provided before the use of either the UVC or the disinfection nebuliser.

- END OF REPORT –

Digitalisation and Technology Division

Electrical and Mechanical Services Department

5th May 2020

Reference and Appendices

- International Commission on Non-Ionizing Radiation Protection