## Utilization Certificate for Sponsored Research Project

**Date: 24/04/2023**

**Subject: Utilization Certificate of research projects sponsored by Government agencies**

The following table shows the total grant received against the mentioned project, the status of the project, and the utilization of the grant for research projects sponsored by government agencies.

| Year of Sanction | Title of Project | Approved Amount (INR in lakhs) | Amount Received till date (INR in lakhs) | Utilization Amount till date (INR in lakhs) | Status/ Remark |
|---|---|---|---|---|---|
| 2021-22 | Design and development of a fuel-flexible burner for domestic and community cooking applications | 24.93 | 0.00 | 0 | The amount has been credited in host institute account |
| 2021-22 | Rescue Support Robotics for Earthquake Situations | 36.17 | 28.28 | 28.28 | Ongoing |
| 2021-22 | Retrofitting of 3D Printer for Pharmaceutical printlet drug delivery system | 2.5 | 2.50 | 2.49 | Completed |
| 2021-22 | Mushroom farming through the substrate generated by the daily bio-degradable waste procured | 2.0 | 2.00 | 2.00 | Completed |
| 2021-22 | Stubble to Sanitary Pads (S2S) | 1.8 | 1.31 | 1.31 | Ongoing |

Accounts Officer

MARWADI UNIVERSITY * RAJKOT *

# INDEX

**PROJECT PROGRESS REPORT**

**Physical & Financial progress of Project**

# Design and development of a fuel-flexible burner for domestic and community cooking applications

Project funded by Petroleum Conservation Research Association (PCRA), Ministry of Petroleum & Natural Gas, Government of India.

**PI:** Dr. Saravanan Balusamy, Department of Mechanical and Aerospace Engineering, Indian Institute of Technology Hyderabad, Kandi.

**Co-PI:** Dr. Parag Rajpara, Department of Mechanical Engineering, Marwadi University, Rajkot.

| No. | Description | Details |
|---|---|---|
| 1 | Name of the Project / Study | Design and development of a fuel-flexible burner for domestic and community cooking applications |
| 2 | Project PI | Dr. Saravanan Balusamy, IIT Hyderabad |
| 3 | Project Co-PI | Dr. Parag Rajpara, Marwadi University, Rajkot |
| 4 | Approved Total Cost for project | Rs. 24.93 Lakhs |
| 5 | Total amount released from PCRA (1st installment) | Rs. 6.20 Lakhs |
| 6 | Actual expenditure | Rs. 4,67,274 /- |
| 7 | Contribution by Project developer, if any | Nil |
| 8 | Objectives of the project | • To assess the performance of a conventional cooking burner using LPG. If necessary, appropriate design modifications in terms of burner port size, mixing tube size, and burner material will be carried out, and the best configuration will be identified.<br>• To employ the heat recirculation technique of PMC to enhance thermal performance and lower emissions. Optimization of porous structure and material will be realized to exploit the maximum benefit of the PMC technique. |

| | | |
|---|---|---|
| | | • To introduce a swirling flow technique to enhance the mixing and flame stability of a cooking burner for various operating conditions using LPG as a fuel.<br>• To perform the comparative performance analysis of developed cooking stoves with and without porous radiant burners and swirl burners for LPG. |
| 9 | Duration of the Project (in months) | 24 |
| 10 | Start / MOU Date and Zero Date | MoU Date: 17/05/2022, Zero Date: 16/06/2022 |
| 11 | Scheduled completion date | 15/06/2024 |
| 12 | Revised completion schedule | NA |
| 13 | Planned work up to the quarter (physical), indicate milestones on quarterly basis | 1. Manpower recruitment – Period: 0 – 2 months<br>2. Design and development of experimental setup – Period: 0 – 9 months<br>3. Procurement of equipment – Period: 1 – 6 months<br>4. Installation of the LPG Stove and preliminary tests – Period: 2 – 9 months |
| 14 | Actual progress (physical) with respect to milestones | 1. Manpower recruitment is completed.<br>2. An experimental setup is designed and realized in our combustion lab. The main components are the commercial LPG stove, mass flow controller for the fuel metering, fume hood, aluminum pans of various sizes, thermometer, and exhaust gas analyzer.<br>3. A few commercial LPG gas stoves are procured. An exhaust gas analyzer is procured with the support of other project funding. The fume hood and base support for the gas stove are procured and installed.<br>4. Preliminary tests are conducted to know the thermal efficiency and emission levels of commercial LPG gas stoves. |

| | | |
|---|---|---|
| | | 5. New swirl burners are designed for domestic cooking stove applications and 3D printed using our in-house metal printer.<br>6. Preliminary tests are going on with the 3D printed burners.<br>7. Base support for the burner is under fabrication, which will give 360-degree optical access between the burner cap and the bottom of the pan. |
| 15 | Reasons for shortfall, if any | Nil |
| 16 | Asset procured, if any (give details) | LPG gas stoves, aluminum pans, burners, thermometer, fume hood, base support, weighing scale |
| 17 | Projected expenditure for the next quarter | Rs. 6 Lakhs |
| 18 | Details of publication of article / paper with respect to project, if any. | Nil |
| 19 | Filing of Patents / awards /Commercialization related to Project. | Nil |
| 20 | Any other Information | Nil |

Date: 29/4/2023

Dr. Saravanan Balusamy

Signature and Name of Project PI

Dr. Parag Rajpara

Signature and Name of Project Co-PI

భారతీయ సాంకేతిక విజ్ఞాన సంస్థ హైదరాబాద్
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

కంది, సంగారెడ్డి-502 284, తెలంగాణ, భారత్
ఫోన్: (040) 2301 6999 ఫ్యాక్స్: (040) 2301 6000
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PCRA/MAE/F151/2022-23/G477

11-04-2023

**Annexure D**

**Utilizattion Statement of Expenditure**
**From the period 09.05.2022 to 31.03.23)**

| Sr No | Funds Allocated as per MoU (Rs.) (II) | Total Sanctioned | Fund released by PCRA (Rs.) | | Expenditure Incurred (Rs.) | | Balance (Rs.) | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | Till Previous instalment | Current Installment | Till Previous instalment | Current Installment | | |
| 1 | Capital items | 480000 | 0 | 47000 | 0 | 29779 | 17221 | |
| 2 | Chemical/ Raw materials | 0 | 0 | 0 | 0 | 0 | 0 | |
| 3 | Consumables | 417900 | 0 | 100000 | 0 | 53573 | 46427 | |
| 4 | Utlilities | 0 | 0 | 0 | 0 | 0 | 0 | |
| 5 | Consultancy | 0 | 0 | 0 | 0 | 0 | 0 | |
| 6 | Travel | 30000 | 0 | 7652 | 0 | 3574 | 4078 | |
| 7 | Stationery | 0 | 0 | 0 | 0 | 0 | 0 | |
| 8 | Manpower | 922560 | 0 | 307520 | 0 | 223200 | 84320 | |
| 9 | Workshop/ Seminar | 20000 | 0 | 0 | 0 | 0 | 0 | |
| 10 | Miscellaneous/ Contingency | 50000 | 0 | 15000 | 0 | 14320 | 680 | |
| 11 | Overhead 10% | 192052 | 0 | 47766 | 0 | 47766 | 0 | |
| 12 | GST@18% | 380252 | 0 | 95062 | 0 | 95062 | 0 | |
| | **Total** | **2492764** | **0** | **620000** | **0** | **467274** | **152726** | |

| | | | | |
|---|---|---|---|---|
| 13 | Interest Non-R | | | **2745** |

Certify that the travelling expenditure are related to the project only.

Copy of proof of expenditure towards (1), (5), (8), (9)

Principal Investigator
Date: 11-04-2023

12/4/23
Competent Financial/Audit authority
Date: 11-04-2023
N. SRISAILAM
Assistant Registrar
IIT HYDERABAD
Kandi, Sangareddy - 502 285

12/4/23
Head of the Institution
Date: 11-04-2023
गाजुला ओशोक / Gajula Ashok
उप कुलसचिव / Deputy Registrar
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad
कंदी, संगारेड्डी-502 284 तेलंगाना, भारत
Kandi, Sangareddy-502 284, Telangana, India

**Date of Sanction:** 25th March, 2021

1. **Principal Investigator (Name & Address):** Dr. Rajendrasinh Jadeja, Dean – Faculty of Engineering, Marwadi Education Foundation's Group of Institutions, Rajkot Morbi Road, Rajkot-360003, Gujarat, India.
2. **Program Title:** Rescue Support Robotics for Earthquake Situation
3. **Date of Commencement of Program:** 31st March 2021
4. **Duration of Project:** 3 years
5. **Amount Sanctioned by GUJCOST:** Rs. 36,17,020/-
6. **Amount Released by GUJCOST:** Rs. 18,95,310/-
7. **Detail of Expenditure:**

| Sr. No | Type of Expense | Items | Budget (In Rupees) 1st Year |
|---|---|---|---|
| 1 | Recurring | Salary/Fellowship | 3,60,000/- |
| 2 | | Consumable | 8,27,620/- |
| 3 | | Travel | 50,000/- |
| 4 | | Contingency | 50,000/- |
| 5 | | Overhead | 3,18,899/- |
| 6 | Non-Recurring | Permanent Equipment | 2,43,900/- |
| | **Total Expenses** | | **18,50,419/-** |

8. **Whether there is any deviation from the purpose for which Grant was released. If so detail of amount to be given**

At present there is no deviation from the objective for which the grant was released.

9. **Give details of the activities carried out during the year:**

The activities carried out during the first year has been listed below here:

1. Literature Review
2. Prototyping of proposed mechanism
3. Procurement of Items and Consumables

## 1. Literature Review

To understand the problem and know about the recent advances in the field the literature review has been carried out. From the literature review, we identified the gap in the work carried out to advance the study efficiently. Based on the literature review, a hybrid system consisting of UAV and ground bot is proposed that can efficiently run the search and rescue operation. The literature review is presented here and the mechanism for both the air support and ground support is also discussed with communication between these two bots.

During natural disasters, time is a crucial factor especially when the search and rescue operations are carried out. The response time after these disasters plays a major role and can be lifesaving. Human efforts sometimes are time-consuming as there are so many variables that affect the operation and the error in the judgement can be life-threatening. So, a quick response will be critical for search and rescue during such conditions. During earthquake-like situations, it is not possible for humans to run rescue operation especially multiple collapse of building occur. This leads to the situation where multiple humans are trapped under debris and rescue operations are affected due to the limited local facilities. For situations like this, an aerial and ground support from robots and UAVs will be most effective for immediate search and rescue operations. The aerial vehicle can provide a wide-angle to decide the rescue plan and the small ground vehicle which can enter any small places can execute that particular plan.

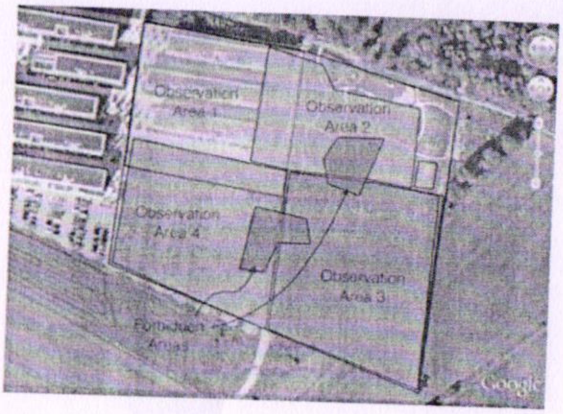


**Fig.1** Use-case for Ref. [1]

Baudoin et al. presented a view finder robot which in case of fire or any such crisis can gather the background information. The main aim behind this robot was to determine whether the affected area was safe for a human to enter as it is a very time-consuming pre-requisite that could delay the rescue mission [2]. The view-finder robot with the main task of data gathering was equipped with sensors that can detect any harmful or flammable substance and in parallel data in form of an image was forwarded to an advanced control station. Quaritsch and co-authors designed networked UAVs as aerial sensor networks for disaster management applications equipped with cameras and sensors. UAVs are helpful to obtain aerial views which can be very helpful to assess the situation during the time of disaster management [1]. This paper presented the several UAVs flying in flight formation to fly over an affected area and information in form of images or videos were forwarded towards the user to make informed decisions for disasters such as flood, earthquake, etc. They have considered a use-case with a forbidden area as shown in the following figure.

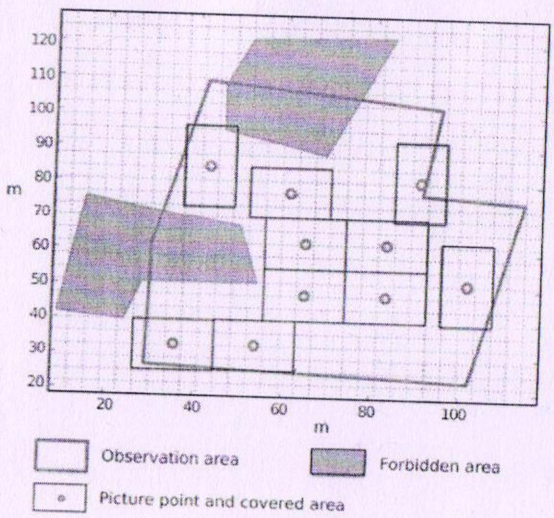


**Fig. 2** Optimized picture taking the position for Ref. [1]

The three main steps performed by the system for generating an overview image are after assessing the user's provided images: (1) planning the mission, (2) executing the mission, and (3) analyzing the image data. With the abilities of UAVs and sensors, the first step is to determine the optimized position of image capturing to minimize the no. of images such that it covers the whole area as shown in Fig. 2. The next step is to compute the routes for the UAVs so that each picture point is visited while minimizing the energy consumption of each UAV and distributing the workload equally. The plan was then sent to the UAVs which fly individually or in formations sensing the environment.

As we can observe in Fig. 3 the naïve approach doesn't cover the entire area and about 45% of the forbidden area is not covered in this approach which is improved in optimized solution as we can observe in Fig. 3. The results of this approach compared with the normal scenario is shown in Table 1.

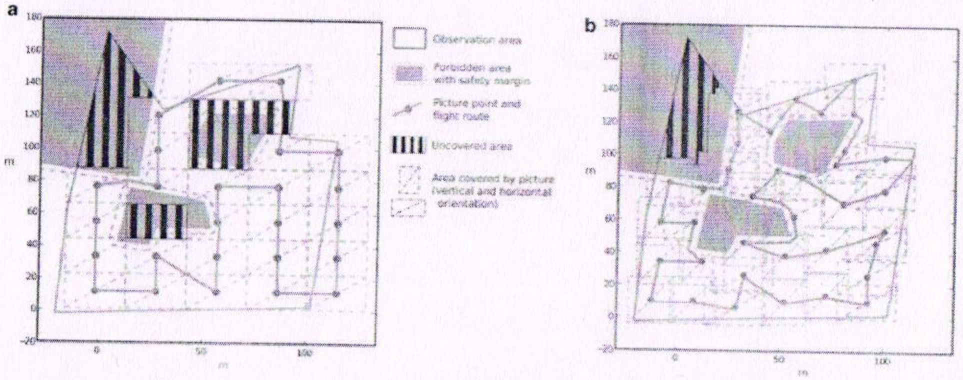


**Fig. 3** Comparison between naïve approach and optimized solution for Ref. [1]

**Table 1** Performance of the proposed scheme and comparison with Naïve approach

| | **Naive Approach** | **Optimized Solution** |
|---|---|---|
| **No. of pictures** | 25 | 38 |
| **Uncovered forbidden area** | 2118 $m^2$ | 875 $m^2$ |
| **Route length** | 550 m | 820 m |
| **Picture point computation** | 1 s | 6.47 s |
| **Route optimization** | 3.12 s | 2.95 s |
| **Total computation time** | 3.12 s | 9.42 s |

Habib et al. have presented a paper that discussed the rescue robotic challenges and necessary technical specifications and functionalities and also briefly described the rescue robotics project [3]. They have briefly discussed about service robots which can be applicable as the helpers of elderly or infants. Later, they covered the role and requirements of robots working in a harsh, dangerous condition which can be applied for search and rescue operations with different types of robots such as UAV, UGV, USV, space robots, and medical robots. An example of UGV is the SR-10 inspector developed by PIAP is equipped with a crawler drive with variable geometric structure as shown in Fig. 4. The developed robot can move under difficult terrain conditions, inside of rooms, and also on stairs with a maximum speed of over 16 km/h. At last, they concluded with a list of challenges in the application domains of robotics for disaster missions and risky intervention.

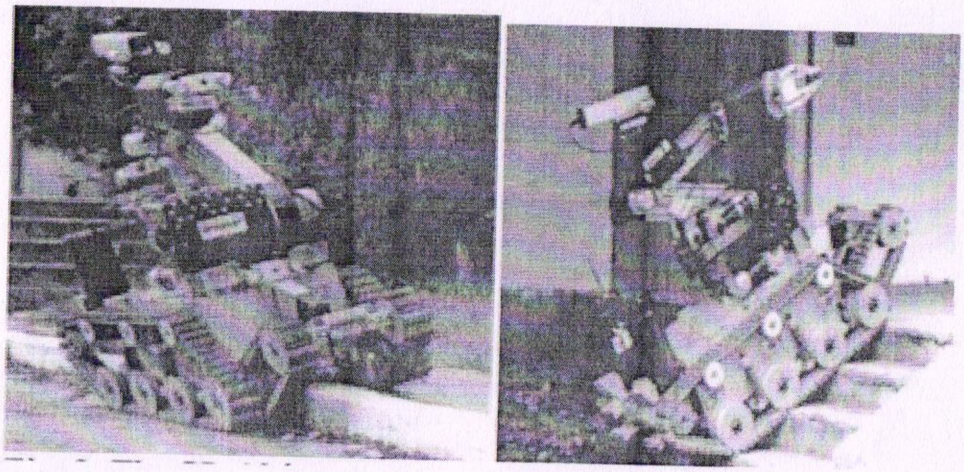

**Fig. 4** SR-10 Robot [3]

Restas presented a paper on drone applications in disaster management supporting role [4]. He reported the usage of UAVs during different kinds of natural or human-made disasters including floods, earthquakes, forest fires to nuclear accidents. S. Tadoloro presented challenges of disaster robotics [5]. The great eastern Japan earthquake was the first instance where robotics systems were used for disaster assistance. This paper discussed the state of art disaster robotics and the current gap in the field. The quince robot shown in Fig. 5 was used in Nuclear Reactor buildings at the Fukushima-Daiichi Nuclear Power Plant accident in 2011. Image, radiation dose

**Fig. 5** Quince Robot [4]

rate, sampled dust, temperature and humidity taken by Quince contributed significantly to planning of cool-shutdown and decommissioning of the reactors. Active Scope Camera (ASC) a serpentine robot was applied to for forensic investigation of structural collapse during construction in Jacksonville, 2008 for search and rescue in debris. It captured video image 8 m deep and gave important data of cause of accident.

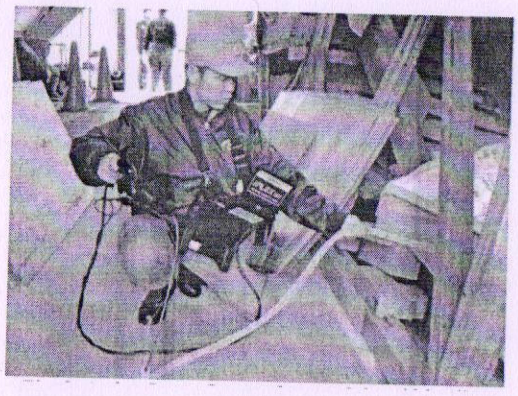

**Fig. 6** ASC – A serpentine Robot [4]

Harvey et al. presented a paper on drones with thermal infrared cameras for a particular location in New Zealand for the purpose of accurate thermal mapping of the large, inaccessible area [6]. In this paper, they have presented a 2.2 $km^2$ georeferenced, temperature-calibrated orthophoto of Waikite geothermal area with more than 6000 images taken over the period of 2 weeks. They noted the 36 MW heat loss from thermal lake and streams in the survey area due to the temperature calibration. The main aim was to find warm springs or other such features in difficult terrain such as wetlands and to provide heat loss estimation. They used the DJI phantom 2 vision+ quadcopter with ICI thermal camera as shown in Fig. 7.

**Fig. 7** Phantom 2 quadcopter with ICI thermal camera [6]

Erdelj presented a survey of UAVs for disaster management including disaster prediction, assessment, response based on the interaction between UAV and wireless sensor network [7]. In particular, they have presented an approach for classifying disasters and outlined suitable network architectures for effective disaster management. UAVs are really useful in disaster management but they are mostly used for monitoring, disaster information sharing, logistic and evacuation support, damage assessment, and search and rescue missions (SAR), etc. They have proposed operational functionality of UAV in natural disaster management is shown in Fig. 8.

Hashim and co-authors presented a development of a drone-based search and rescue operation for the Malaysia flood disaster and evaluated the accuracy of victim detection [8]. As the drone has a limited duration of the flight, search and rescue should be directed in an optimal

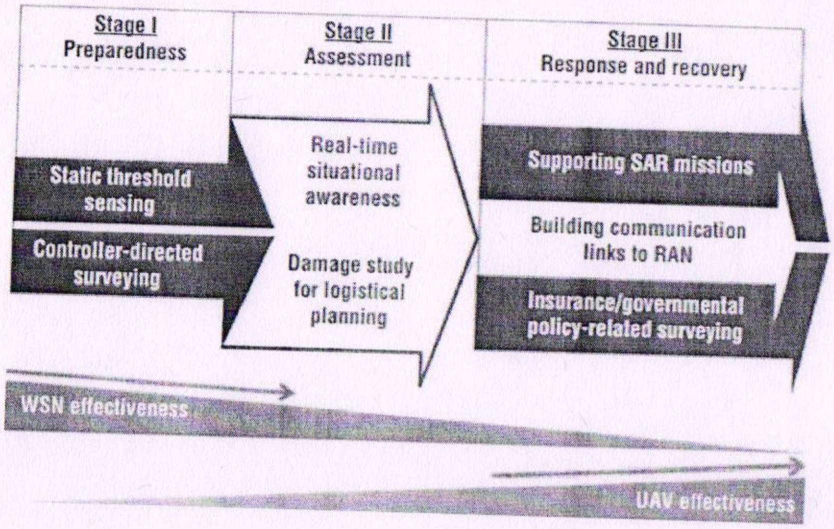


**Fig. 8** Proposed functionality of UAV in disaster management from Ref. [7]

path. First, we need the optimal area where the victims are most likely to be found. Then we need to divide the main area into sub-areas for assigning search patterns and select search patterns in a way it optimally covers the sub-area and various search patterns are demonstrated in Fig. 9. They designed the prototype using a medium-sized quadcopter, transmitter, mobile phone, Arduino UNO R3, GPS/GPRS/GSM module v3.0, and the results were compared between the GPS response and mobile response. This was carried to make sure the system receives the message as well as can send a reply to the rescuer. During 20 trials they conducted, some required more than one request message to reply the location of the victim due to the GSM module failure.

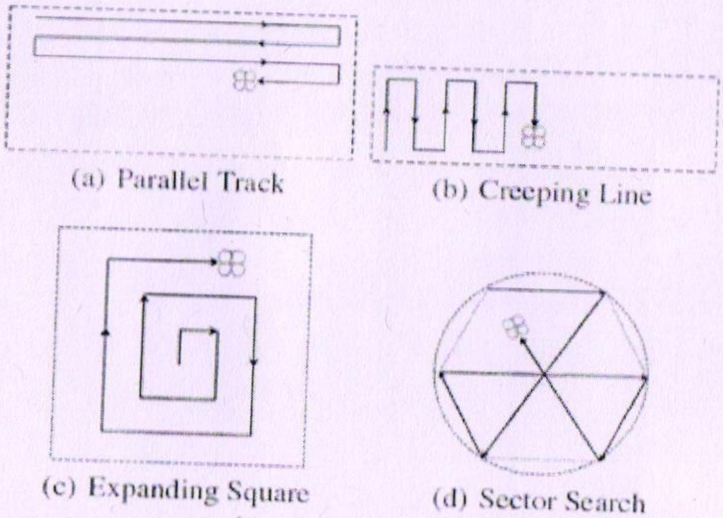


**Fig. 9** Search patterns used by drone

Luo presented a chapter containing communication and network technologies that are used in UAV disaster management systems [9]. Fig. 10 shows the network architecture consisting of wi-fi, 2G/3G/4G cellular network and GPS assisted satellite network. As we can observe, UAVS connect to GPS satellite network using GPS receiver which time to time provides geolocation and timestamp which are critical during disaster response. Figure 11 depicts the entire architecture of a UAV-based cooperative wireless network deployed across a vast geographic area to give disaster-affected areas with on-the-fly communication capabilities. UAVs are employed as communication relays in such scenarios to bridge communication in areas where part of the communication infrastructure has been destroyed by natural catastrophes such as earthquakes, floods, or man-made disasters such as bomb blasts, military attacks, and so on. They designed an optimal UAV deployment algorithm (OUDA) to quickly deploy the UAV to the ideal position for bridging communication between ground nodes and providing the best communication facilities to the participating ground stations. The algorithms are set up in such a way that the UAV will begin flying toward the catastrophe region and broadcast beacon messages at regular intervals. When the participating nodes get the beacon message, they respond by sending their ID and GPS position to the UAV. The UAV will also measure the received signal strength (RSS) and the distance between it and the ground nodes.

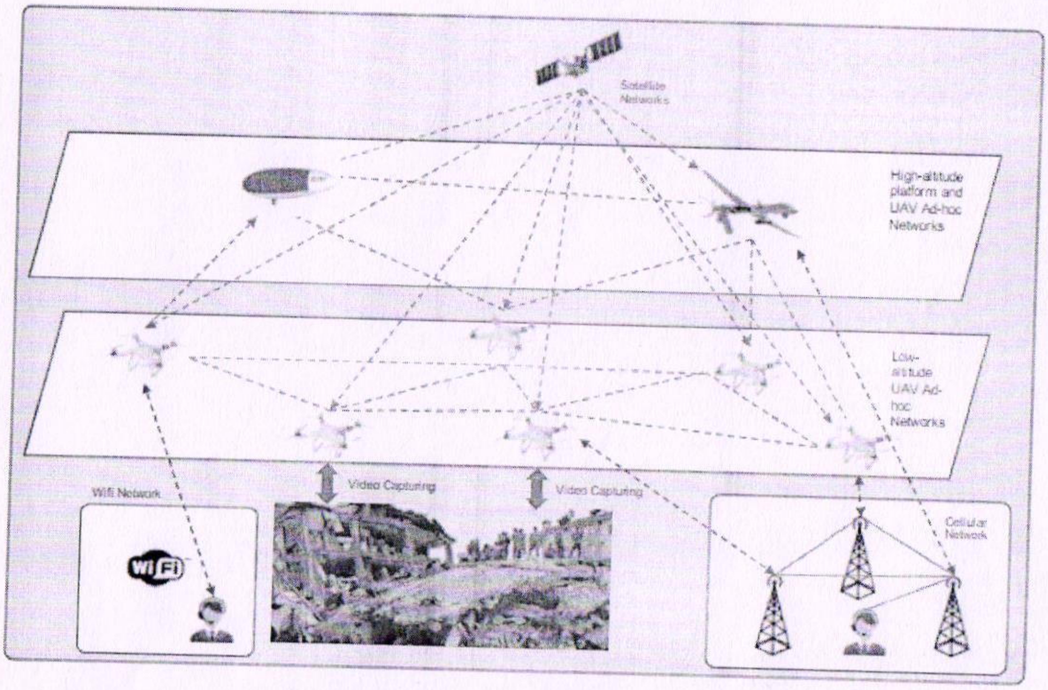


**Fig. 10** A network architecture for UAV-based disaster management system

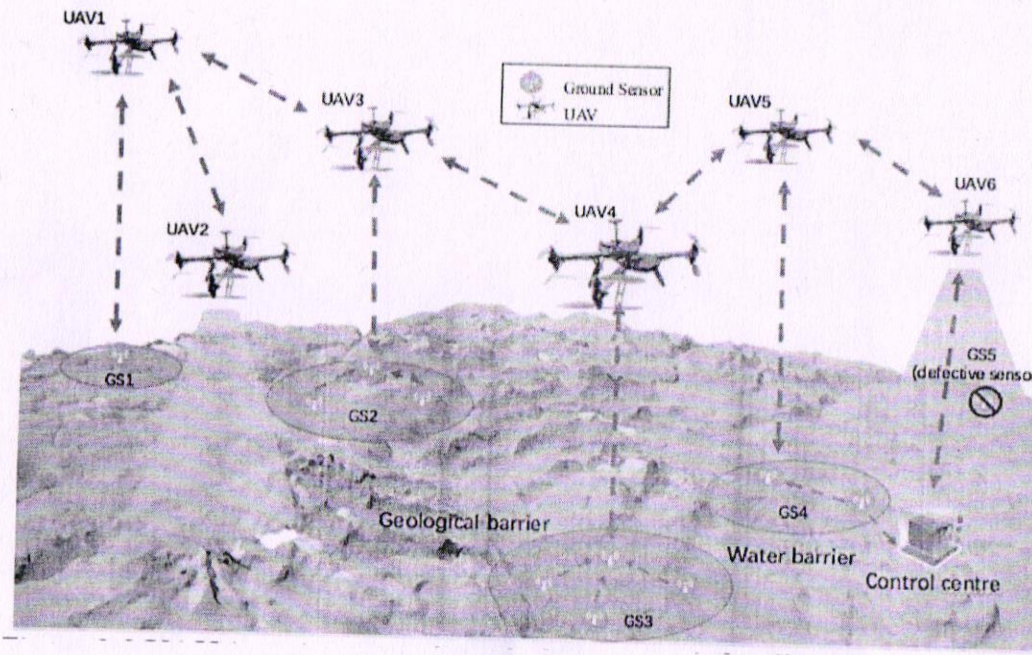


**Fig. 11** Bridge communication between several UAVs

Abraham et al. presented a paper on swarm robotics in disaster management [10]. Swarm robotics due to its robust and flexible nature can access the area which is otherwise a difficult task. The main aim was to detect any life form stuck in any danger zone and show its way out by performing coordinated movements. There are several existing projects such as the SENEKA project with the aim of surveying the site and searching for a source of danger and victims using swarm robots with dynamically networkable sensors [11]. Researchers at Carnegie Mellon University are designing intercommunicating miniature drones which can enter the building after the disaster and give critical information and create a two-dimensional map. A social drone is a Mumbai-based startup that documented and helped a lot in search and rescue operations during Uttarakhand floods. It surveyed Uttarkashi, Gangotri, and Maneri and gathered huge content. Abraham has suggested a drone system that can help deliver medical supplies using a GPS module with the help of a latitude and longitude tracking system or can detect victims at such locations.

Sanfilippo and co-authors presented a review on perception-driven obstacle-aided locomotion for snake robots [12] that could be used to transfer tools and assembled with sensors into dangerous or restricted regions which are out of reach for other robots and humans. Perception-driven locomotion and obstacle-aided movement are required for snake robots to perform these tasks. In order to understand the wide range of real-world applications for snake robots, such as firefighting, industrial inspection, and search and rescue, these aspects are critical. The work presented a comprehensive analysis of the current state of the art, obstacles, and potential of perception driven obstacle-aided locomotion for snake robots. Authors focused on current approaches to obstacle avoidance, obstacle accommodation, and obstacle-aided locomotion in the context of snake robots. As a result, they considered obstacle-aided locomotion in terms of perception and mapping. Therefore, we've compiled a list of crucial technologies and approaches for perception-driven obstacle-assisted locomotion, such as mapping and representation. One of the most appealing approaches to fully emulate the movement of biological snakes is to build a robotic snake with such agility. One of the main reasons for the creation of such a robot is the wide range of uses it may be put to, such as pipe inspection for the oil and gas industry, firefighting, and search-and-rescue. The basic concept of this is presented in Fig. 12. For obstacle tackling three possibilities were discussed. In the traditional approach, Artificial Potential Field theory has been used to effectively model imaginary force fields surrounding things on the robot that are either repulsive or appealing. Force fields generated by the target location attract the robot, whereas those generated by other robots, obstructions, or the robot itself repel it. It is possible that these forces will get more powerful as the robot draws nearer. It was built on these concepts that an obstacle avoidance controller appeared [13]. The second approach is known as obstacle accommodation.

In order to avoid obstacles, it is possible to take a more relaxed approach by leveraging sensory feedback. The collision between the snake robot and obstacles are possible; however, any collisions must be carefully regulated to prevent harm to the snake robot. In [14], a motion planning system was built to allow a snake-like robot to be able to navigate around obstacles in its path. Motion restrictions caused by contact with impediments were first formally formulated in [15]. Based on this formulation, a novel inverse kinematics model was built that enables joint motion for snake robots under contact limitations. With this paradigm, a snake robot motion planner was also presented for complex environments.

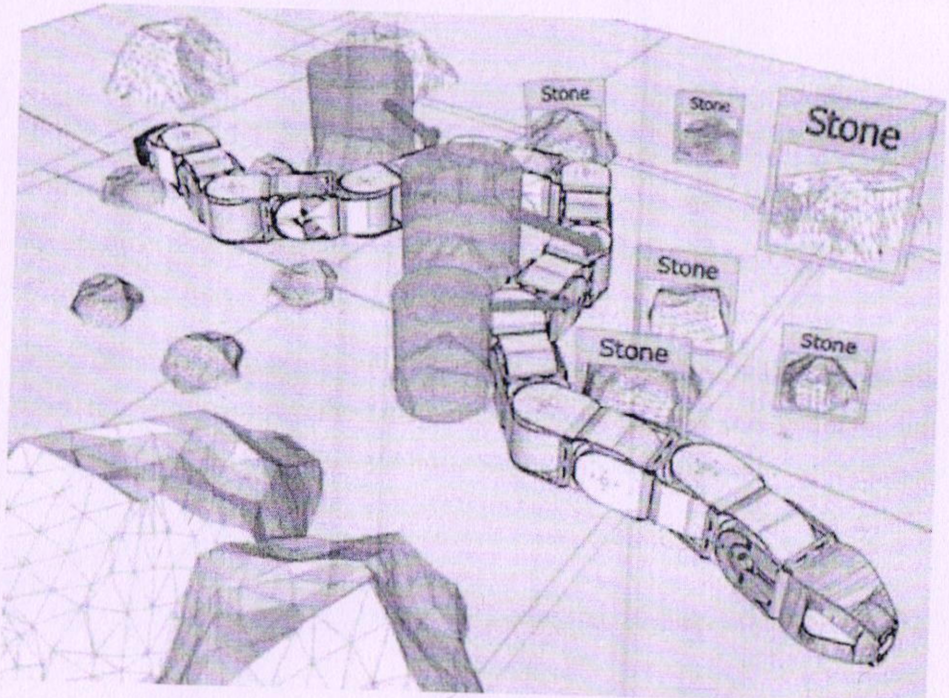


**Fig. 12** The basic concept of snake robot perception-driven obstacle-aided locomotion [12]

It has been found in nature that biological snakes exploit terrain irregularities and push against them when moving over lateral undulations in order to create a more effective locomotor stride. Furthermore, the entire body of the snake is bent, with all portions following the direction of its head and neck. Kelasidi et al. reported an innovation in underwater robots [16]. For biologically inspired swimming snake robots, experimental results for LOS path-following control were provided. An underwater snake robot controller that could handle both lateral undulation and eel-like motion patterns was proposed. The robot was guided to its destination using LOS guidance and a directional controller. There are three primary parts to the proposed path-following controller: There are three components to the Line of Sight (LOS) guidance law: 1) the gait-pattern control system that generates a sinusoidal motion pattern that drives forward, 2) the heading controller that steers the robot toward and then along the desired path, and 3) the LOS guidance law that generates the desired heading angle. Underwater snake robots can be programmed to follow straight lines using the proposed control method. Fluid parameter identification and simulation results based on the identified fluid coefficients were presented to compare the physical robot's motion with simulation results during the experiments. For both lateral undulation and eel-like motion patterns, the experimental results showed that the suggested control approach successfully directed the robot toward and along the target path. There will be more work done to test the efficacy of this control method for broad path-following control applications in future works by the authors. In the future, the fluid coefficient identification scheme should be tested in conjunction with current effects. It is possible to employ force/torque sensors implanted in the modules of the robot to identify fluid coefficients more precisely with and without the effects of currents. In addition, the idea of extending the control strategy to 3-D and thus investigating depth control tactics for underwater snake robots is an attractive issue for future exploration. To develop underwater snake robots for demanding real-time subsea activities, an experimental inquiry into the path following of underwater snake robots in 3-D is required.

Kormushev and co-authors reported an important role of reinforcement learning in robotics and its applications and challenges faced real world [17]. Robots can learn, improve, adapt, and reproduce tasks with dynamically changing constraints by exploring and learning on their own. This is the primary goal of reinforcement learning in robotics. Robotics-related reinforcement learning algorithms and policy representations were summarized in the paper. Robotics policy representation faces a slew of difficulties. Reinforcement learning may be used for a variety of real-world tasks, including pancake flipping, bipedal walking energy reduction, and archery-based aiming. Different policy representations are presented and assessed for each task in a state-of-the-art expectation-maximization-based reinforcement learning model. Six rarely addressed difficulties in policy representations are addressed by the suggested policy representations: correlations, adaptability, multi-resolution, globality, multi-dimensionality, and convergence. As a result, these examples examine both their triumphs and their shortcomings in practice. It is possible to draw inferences about the state of the art and future directions for reinforcement learning in robotics based on these specific situations.

Peng and co-authors reported a new approach to learning agile robotic locomotion skills by imitating animals [18]. It has been a persistent difficulty in robotics to replicate the diverse and nimble movement talents of animals. While manually designed controllers have been able to replicate many complicated behaviors, constructing such controllers involves a time-consuming and demanding development process, typically requiring substantial experience of the complexities of each ability. To automate controller development, reinforcement learning is a good option. However, creating learning objectives that motivate an agent to behave in a particular way can necessitate a high level of expertise in the particular field. To teach legged robots nimble mobility, authors devised an imitation learning system that used real-world animals to teach them how to move quickly and efficiently. The work demonstrated that a single learning-based technique can automatically synthesize controllers for a wide range of legged robot behaviors by using reference motion data. The system presented in the paper can learn adaptive policies in simulation and then swiftly adapt them for real-world deployment by introducing sample efficient domain adaptation approaches into the training process. With the help of an 18-DoF quadruped robot, authors illustrated the efficiency of the method by teaching it a wide range of nimble behaviors.

Hirose et al. presented mathematical modeling for biologically inspired snake robots [19]. Smaller active endoscopes, a large-sized snake-like inspection robot for nuclear reactor-related facilities, Koryu, and numerous other snake-like robots are also available. One of the most recent study subjects is the creation of snake-like robots. Because of previous research, they expect snake-like robots will soon be used in a practical manner. Moerland and co-authors surveyed the emotion in reinforcement learning agents and robots [20]. The article provided the first survey of computational models of emotion in reinforcement learning (RL) agents. Agent/robot emotions are the center of the survey, while human user emotions are almost completely ignored. Emotions are acknowledged as functional in decision-making by influencing motivation and action selection. RL is a key subclass of the decision-making architecture used by agents, and the most computational emotion models find their foundation in the work. Three research domains benefit from studying the emotions of RL-based agents. For machine learning (ML) researchers, emotion models may boost learning efficiency. Emotions can be used in the interactive ML and human-robot interaction communities to transmit state and increase user investment. Finally, it allows academics in the field of affective modeling to test their hypotheses in a real-world AI agent class.

This survey provided background on emotion theory and RL. How emotions can be modelled in real-life robots, what kinds of emotions may be generated from these fundamental dimensions (e.g., homeostasis or assessment), and how these emotions might either influence the agent's learning efficiency or be used as social signals are all addressed. Authors also systematically examined evaluation criteria, and made connections to significant RL sub-domains like (intrinsic) motivation and model-based RL. In summary, this survey provided interesting and significant information in implementing emotions into their RL agents with a practical overview as well as identifying problems and directions for future research on emotion-RL.

We propose the system equipped with a UAV and a snake robot. The UAV will provide a general scenario of a situation and will point the direction with greater casualties and drop the snake robot at that point to investigate any human casualties. The UAV will be equipped with a normal high-resolution camera and infrared camera to detect humans using deep learning algorithms. We might also add several swarm robots in snake robots which will divide the area within themselves to investigate and communicate with the control station via snake robot/UAV network. We can also launch several snake robots equipped with swarm robots at different casualty areas to optimize the time taken for search and rescue.

## 2. Proposed Mechanism

We propose a hybrid system composed of air support and ground support of UAV and snake robot, respectively. For primary scan, a UAV system will scan the earthquake-affected area utilizing a thermal and conventional camera and will detect human beings that are trapped under the debris in a fast scan. Later, we will divide the affected area into an optimized map as shown in Fig. 2 and Fig. 3 and drop the swarm/single snake robots in those particular areas where UAV cannot locate any human beings and this area will be prioritized accordingly to detect the humans trapped under the debris more efficiently. There will be a control station at an affected site that will collect the data forwarded by both the UAV and Snake robot. The snake robot will be communicating to the control station through the bridge communication with the help of a UAV system that will be stationed in the affected area. Thus, we are proposing an efficient and optimized, and exhaustive search and rescue support mechanism for an earthquake-like natural disaster.

Here we have introduced the drone for the sole purpose of initial screening as the snake robot's speed will be low as it must scan the larger area an initial scan will help to identify the highly affected area and we can drop the snake robot/swarm of snake robots in that area for efficient search and rescue operation. Furthermore, an initial scan with help of a drone will help to detect the human that is trapped on the surface and easily detected resulting into saving of critical time. In addition to that, it is difficult to predict the size of the affected area immediately and the drone will help us launch the snake robot at larger distances. With the help of bridge communication discussed earlier, we can communicate to the snake robot via drone and collect the important data to process. These are the major reasons why we have introduced the drone in our search and rescue mechanism.

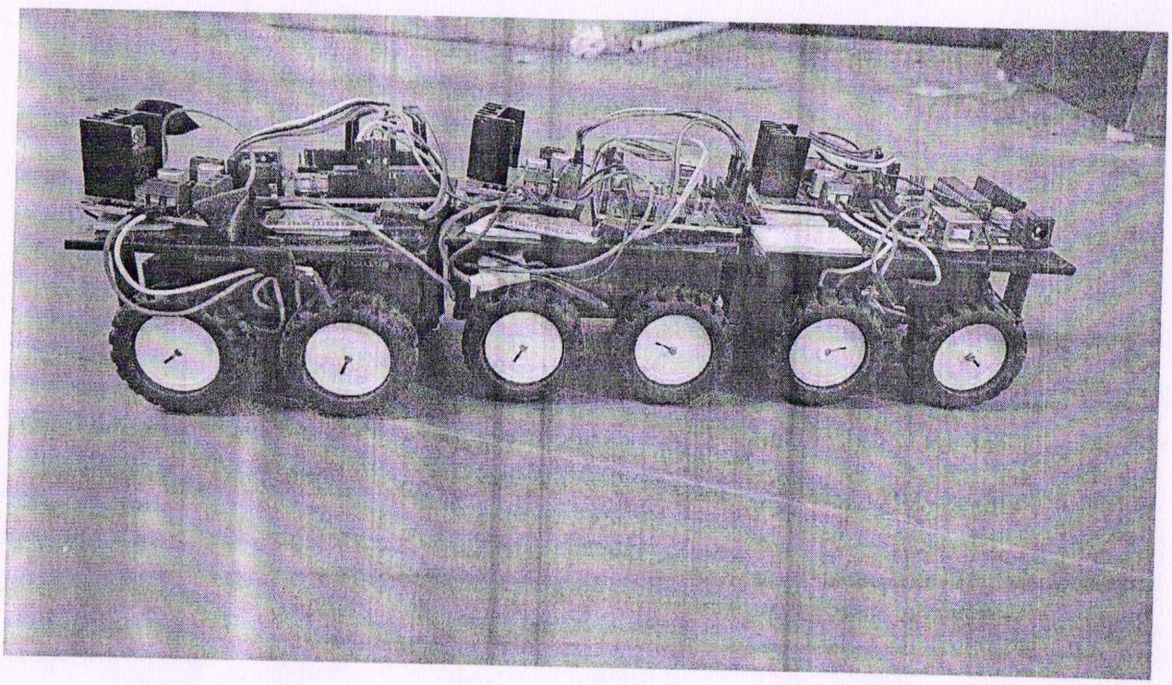

**Fig. 13** An initial testing mechanism designed for snake robot

We have developed a mechanism for identifying a human and the output is reported in Fig. 13. The current size of the single block of the snake robot is 11 cm × 10 cm × 7 cm and further modification are required in the prototype presented in Fig. 13. As the project progresses, we will try to design a compact mechanism for the robot. In Fig. 13, we have only illustrated a testing mechanism for testing purposes. A drone is also being tested and is ready to record videos for further image processing to detect human beings. For the building block of the snake robot, we have compartmentalized the spaces for sensors (cameras, lidars, mike, speakers, etc.), motors, and other essential equipment for the proper operation of the snake robot. A 3D printed block design for a snake robot is in progress that will consist of several sensors to guide the snake robot in the proper direction and send the data to the control station via communication through UAV, and image capturing devices.

We have divided the project into several steps. In the first step, we will design a basic prototype for both the UAV and snake robot mechanism and demonstrate the deep learning-based algorithm for human detection. In the second step, we will try to achieve a snake-like movement and prepare a compact design for the snake robot. In the third stage, a line of sight and path following mechanism will be implemented. Finally, we will work on the UAV and snake robot communication and designing of an accurate algorithm for efficient and early detection of humans trapped under the debris.

## 3. Procurement Details

Fig. 14 illustrates the purchased components for the designing of a snake robot and drone, 3D printer, and the concept of a UAV system. The available materials for the snake robot have larger weight and difficult to operate on the complex surface. Furthermore, the increased weight will slow down the snake robot's speed and can also restrict its movements. This has motivated us to employ materials such as PLA, ABS, TPU, etc. that will allow the snake robot to move in the dense places effortlessly. To design this structure, a 3D printer is procured that is illustrated in Fig. 14. The different material filaments are also illustrated in Fig. 14. Furthermore, the data received from snake robots and UAVs will be very large. Additionally, we'll need a real-time image processing with the help of deep learning algorithms to guide the snake robots in proper direction and detection of humans. This requires faster processing power, so that the system can process the data in efficient time. Additionally, state of the art graphics processing unit will improve the processing in ML/DL algorithms. This has forced investigators to purchase a workstation with high configuration.

For the drone, we have purchased a carbon fiber body frame that will provide a sturdy, and efficient operation in any conditions and Lippo batteries were purchased to achieve the higher flight time as we don't know the exact flight time beforehand and to keep in mind the operation time, we have decided to purchase Lippo batteries and to achieve higher resolution a high-resolution camera is also purchased this all equipment are presented in Fig. 14.

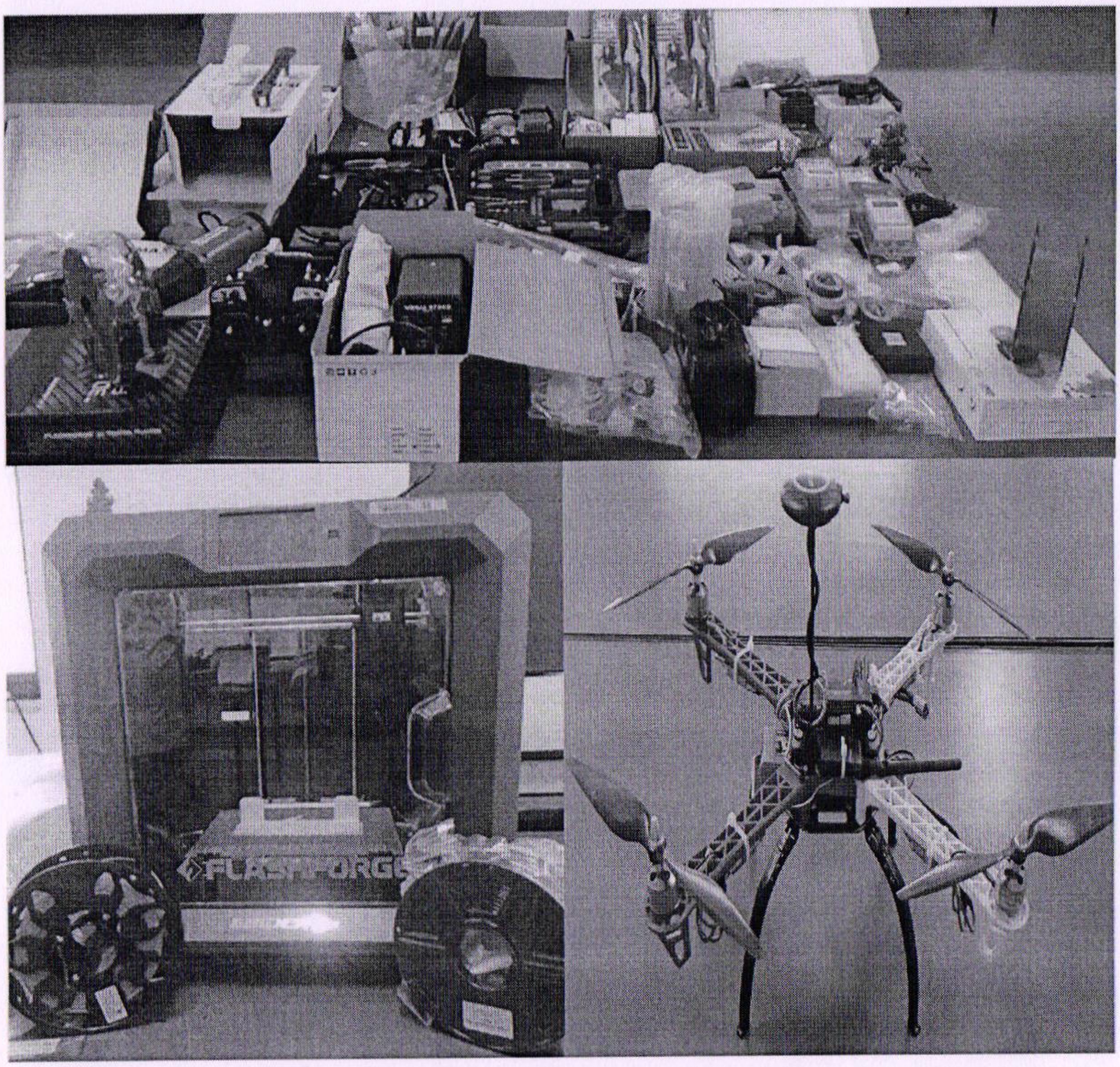


**Fig. 14** Purchased component, 3D printer with the concept of UAV system

**Benefit to Stakeholders:**

The ongoing research work has benefitted multiple stakeholders in the university. While the research work is carried out with the objective to develop a robot for rescue of human beings trapped under the debris, several alternative solutions have emerged out of discussion with graduate, and undergraduate scholars. In addition to this, no. of undergraduate students has expressed immense interest in developing the solution which are indigenous and specific to the need of Indian conditions. A team has been formed to work on the current project.

Following are the details of the team:

**PI:** Dr. R.B. Jadeja

**Co-PI:** Dr. Tapankumar Trivedi

**Junior Research Fellow:** Mr. Jaymit Surve

**Faculty Co-ordinators:** 1. Mr. Akshay Ranpariya

2. Dr. Dinesh Kumar

**Student Team:** 1. Bhavdeep Singh Krishnawat

2. Dushyant Bagthariya

3. Viraj Shekhda

4. Dev Soni

5. Raj Panjwani

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Principal Investigator | Co-PI | Registrar/~~Director~~/~~Principal~~

(Signature & Seal)

MARWADI EDUCATION FOUNDATION RAJKOT

# GRANT UTILIZATION CERTIFICATE

Certified that M/s. Marwadi Education Foundation having its registered address as MEFGI Campus, Near Guaridad, Rajkot-Morbi Highway, Rajkot-360003. Received grant of **Rs 18,95,310/-** grants-in-aid sanctioned during the year **2021-22** from the GUJCOST vide letter No. **GUJCOST/STI/2020-21/2271** dated **25/03/2021**. Out of that Grant **Rs. 44,891/-** remains unspent balance of previous year, and sum of **Rs. 18,50,419/-** has been utilized for the purpose of Major Research Project for which it was sanctioned and that the balance of **Rs 44,891/-** remaining unutilized at the end of the financial year 2021-22, will be adjusted towards the grant-in-aid payable during the next year i.e. 2022-23.

**For, Marwadi Education Foundation**
**Signature of Principal Investigator**
**23/04/2022**

MARWADI EDUCATION FOUNDATION RAJKOT

**For, CA Hardik Dhulia & Co.**
**Chartered Accountants**

CA. HARDIK DHULIA RAJKOT M. No. 134888

**CA Hardik Dhulia**
**M.ship No. 134888**
**UDIN: 22134888AHTPXT2596**

**Date: 01/05/2023**

## UTILIZATION CERTIFICATE

Certified that M/s. Marwadi Education Foundation having its registered address as MEFGI Campus, Near Gauridad, Rajkot-Morbi Highway, Rajkot-360003 received grant of **Rs 9,33,540/-** grants-in-aid sanctioned during the year **2022-23** from the GUJCOST vide letter No. **GUJCOST/STI/R&D/ 2022-23/2253** dated **27/09/2022.** Out of that Grant **Rs. 44,891/-** remains unspent balance of previous year and sum of **Rs. 9,78,431/-** has been utilized for the purpose of Major Research Project for which it was sanctioned and that the balance of **Rs 0/-** remaining unutilized at the end of the financial year 2022-23 will be adjusted towards the grant-in-aid payable during the next year i.e. 2023-24.

**For, Marwadi Education Foundation**

**Signature of Principal Investigator**

**01/05/2023**

MARWADI EDUCATION FOUNDATION RAJKOT

**For, CA Hardik Dhulia & Co**

**Chartered Accountant.**

CA. HARDIK DHULIA RAJKOT M. No. 134888

**(CA Hardik Dhulia)**

**Membership No. : 134888**

**FRN: 158300w**

**UDIN : 23134888BGWYPM7813**

Marwadi University

## SUBMISSION OF PROGRESS REPORT 2021-2022

**Project Title:** Retrofitting of 3D Printer for Pharmaceutical printlet drug delivery system

**Name of PI -** Dr Lalji Baldaniya

**Project Description:** The project aims at developing a system where Medicine in a 3D Printer using SLS/SLA 3D Printer based on the Body Mass Index. The quantity of particulars is calculated based on the body mass index and customized medicine will be made.

**Project status at the beginning of the Year:** Ideation

**Interventions Made:** Product – Pharmaceutical

**Current Status:** Prototyping

**Future Plan:** The process is tested and validated as per the standard operating procedure. 3D Printed customized medicine based on BMI is a novel concept that can further be explored based on the opportunity available. The concept shall be protected by filing patents.

**Date:** 25/03/2023
**Place:** Rajkot

Baldania

Dr. Lalji Baldaniya
Principal Investigator
Professor, Faculty of Pharmacy
Marwadi University

Dean – Research
Marwadi University

**Date: 28.04.2023**

# Utilization Certificate for Sponsored Research Project under NewGen IEDC

Project Title: Retrofitting of a 3D Printer to design printlet drug delivery system.

Year: 2021-22

Grant Sanctioned: Rs. 2.50 Lacs

Grant Utilized: Rs. 2.49 Lacs

PI: Dr. Lalji Baldaniya

| No. | Particular | Total Cost (In Rs.) |
|---|---|---|
| 1. | Consumables – Raw materials | 39,147 |
| 2. | Non-Consumables/ Equipment | 1,60,231 |
| 3. | Other Expense - Stipend / Mentorship | 50,000 |
| | **Total** | **2,49,378** |

I/We certify that this amount has been spent for the purpose it was meant for.

Chief Account Officer

MARWADI UNIVERSITY * RAJKOT *

Marwadi University

**Project Title:** Mushroom farming through the substrate generated by the daily biodegradable waste procured at Marwadi University Campus

**Name of PI:** Dr Aditya Saran

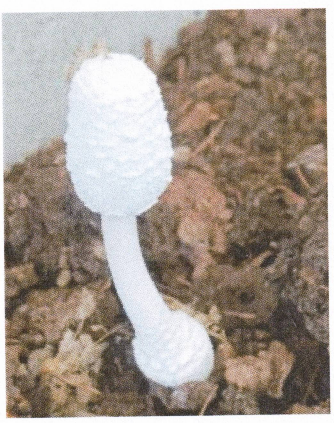
**Project Description:** Mushrooms are a good source of proteins, vitamins, and minerals. The cost of production is low while the value of the product is high. It needs skills. Mushrooms grow on waste products. Here we wish to grow mushrooms on the substrate which will be prepared from the daily biodegradable waste of Marwadi University. Skill is critical and key to success. In addition, we have isolated symbiont /endosymbiont of Pleurotus species responsible for nitrogen fixation. Also, we have developed a new and very low-cost method for sterilization of substrates.

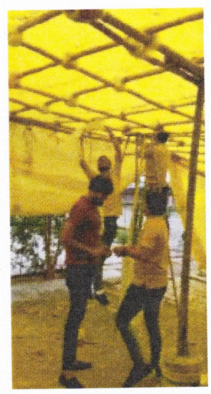
**Project status at the beginning of the Year:** Proof of Concept

**Interventions Made:** Product –Agriculture

**Current Status:** Testing

**Future Plan:** It is expected to have a product and shall apply for testing certificates and shall apply for company registration and patent.





**Date:** 27/03/2023
**Place:** Rajkot

Dr. Aditya Saran
Principal Investigator
Assistant Professor, Faculty of Science
Marwadi University

Dean – Research
Marwadi University

Marwadi University
Marwadi Chandarana Group

Date: 28.04.2023

## Utilization Certificate for Sponsored Research Project under NewGen IEDC

Project Title: Mushroom farming through the substrate generated by the daily biodegradable waste produced

Year: 2021-22

Grant Sanctioned: Rs. 2.0 Lacs

Grant Utilized: Rs. 2.0 Lacs

PI: Dr. Aditya Saran

| No | Particular | Total Cost (in Rs.) |
|---|---|---|
| 1 | Consumables – Raw materials | 158746 |
| 2 | Non-Consumables/ Equipment | 25550 |
| 3 | Other Expense - Services | 16850 |
| | **Total** | **2,01,146/-** |

I/We certify that this amount has been spent for the purpose it was meant.

Chief Account Officer

MARWADI UNIVERSITY * RAJKOT *

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Marwadi University

## SUBMISSION OF PROGRESS REPORT 2021-2022

**Project Title:** Stubble to Sanitary Pads (S2S)

**Name of PI:** Dr Amit Sata

**Name of Co-PI:** Prof Vivek Patel

**Project Description:** Globally, approx. 727 million tons of rice straw and 583 million tons of wheat straw are produced. Southern Asia contributed 215 and 194 million tons respectively. Stubble leads to pollution when burnt and if not does not generate significant income too. So, the innovation proposed is to efficiently utilize Stubble and meet the following aspects.

- Generate cellulose out of the stubble by chemical and mechanical processes.
- Prepare layers of sanitary pads using the cellulose thus generated.
- producing packaging material for pads and disposing of them too.
- Generating a Source of income for the farmers.

**Project status at the beginning of the Year:** Ideation

**Interventions Made:** Product – Agriculture & Healthcare

**Current Status:** Prototype Development

**Future Plan:** Testing and validation of the cellulose for different sizes and types shall be made. Shall apply for the patent for the process developed and shall also apply for design for the structure of equipment developed.

**Date:** 28/03/2023
**Place:** Rajkot

Dr. Amit Sata
Principal Investigator
Professor, Mechanical Engineering
Marwadi University

Mr. Vivek Patel
Co-PI
Assistant Professor,
Mechanical Engineering
Marwadi University

Dean – Research
Marwadi University

**Date: 28.04.2023**

## Utilization Certificate for Sponsored Research Project under NewGen IEDC

Project Title: Stubble to Sanitary Pads (S2S)

Year: 2021-22

Grant Sanctioned: Rs. 1.8 Lacs

Grant Utilized: Rs. 1.31 Lacs

PI: Dr. Amit Sata

| No. | Particular | Total Cost (In Rs.) |
|---|---|---|
| 1. | Consumables – Raw materials | 23,331 |
| 2. | Non-Consumables/ Equipment | 43,338 |
| 3. | Miscellaneous | 24,752 |
| 4. | Other Expense - Stipend / Mentorship | 40,000 |
| | **Total** | **1,31,421** |

I/We certify that this amount has been spent for the purpose it was meant.

Chief Account Officer