Smart Navigation and Dynamic Path Planning of a Micro-Jet in a Post Disaster Scenario

Tamal Mondal  
Department of Computer Application  
Kalyani Government Engineering College  
tamalkalyaniigov@gmail.com

Jaydeep Roy  
Department of Computer Application  
Kalyani Government Engineering College  
jaydeep.kgec@gmail.com

Indrajit Bhattacharya  
Department of Computer Application  
Kalyani Government Engineering College  
indra51276@gmail.com

Sandip Chakraborty  
Department of Computer Science and Engineering  
Indian Institute of Technology Kharagpur  
sandipc@cse.iitkgp.ac.in

Arka Saha  
Department of Computer Application  
Kalyani Government Engineering College  
arkakgecmca@gmail.com

Subhanjan Saha  
Department of Computer Application  
Kalyani Government Engineering College  
subhanjan.saha@gmail.com

ABSTRACT
Small sized unmanned aerial vehicles (UAV) play major roles in variety of applications for aerial explorations and surveillance, transport, videography/photography and other areas. However, some other real life applications of UAV have also been studied. One of them is as a 'Disaster Response' component. In a post disaster situation, the UAVs can be used for search and rescue, damage assessment, rapid response and other emergency operations. However, in a disaster response situation it is very challenging to predict whether the climatic conditions are suitable to fly the UAV. Also it is necessary for an efficient dynamic path planning technique for effective damage assessment. In this paper, such dynamic path planning algorithms have been proposed for micro-jet, a small sized fixed wing UAV for data collection and dissemination in a post disaster situation. The proposed algorithms have been implemented on paparazziUAV simulator considering different environment simulators (wind speed, wind direction etc.) and calibration parameters of UAV like battery level, flight duration etc. The results have been obtained and compared with baseline algorithm used in paparazziUAV simulator for navigation. It has been observed that, the proposed navigation techniques work well in terms of different calibration parameters (flight duration, battery level) and can be effective not only for shelter point detection but also to reserve battery level, flight time for micro-jet in a post disaster scenario. The proposed techniques take approximately 20% less time and consume approximately 19% less battery power than baseline navigation technique. From analysis of produced results, it has been observed that the proposed work can be helpful for estimating the feasibility of flying UAV in a disaster response situation. Finally, the proposed path planning techniques have been carried out during field test using a micro-jet. It has been observed that, our proposed dynamic path planning algorithms give proximate results compare to simulation in terms of flight duration and battery level consumption.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from Permissions@acm.org.

Keywords  
UAV; Survey; paparazziUAV; Battery level; Dynamic; Priority; Flight time; Wind speed.

1. INTRODUCTION

Use of UAV in a post disaster situation is necessary, especially after any large scale disaster. In some recent studies [1, 2], it has been observed that UAVs can be established as an emergency communication system after any large scale disaster. Besides, UAVs can also be very effective for collection of situational information for damage assessment. Due to limitations and challenges of traditional damage assessment technique after “Hurricane Katrina” the authors of have explored the importance of using UAVs as an information collector for damage assessment in a post disaster scenario, as in the trail of any large scale disaster it is necessary to disseminate genuine information for efficient timely response [3, 4, 5]. Furthermore, in [6], the authors have proposed a 4-Tier DTN architecture with UAVs (called as data mules) as a Tier 3 component, acts as a data collector from drop-boxes, situated at shelter points. These studies on UAV penlights it’s usage as a damage assessment component in a post disaster situation. Though the question is that, what should be the ideal climatic condition for a UAV to fly? It is quite obvious that, based on the severity and type of any large scale natural disaster the climatic conditions would also vary. Hence, there must be a predictor that predicts the post disaster environment and suggests a) whether the UAV is capable to fly, b) If it is capable, then what should be the trajectory plan, and c) what should be the required flight duration and battery level required to complete the trajectory plan.

In this work, we have developed such a technique by introducing two novel dynamic path planning methodologies to suggest the possible shelter points to cover in a post disaster situation. In a disaster response scenario, the necessary objective would be to collect genuine situational data from shelter points within a stipulated time. Hence, visiting appropriate shelter points...
are necessary within the allotted flight time of the UAV, which remains a very challenging issue. Furthermore, it is a very challenging task to predict the behavior of UAV under varying climatic conditions with real deployment. In the proposed technique we have tried to elevate such problems. Our proposed work is of fourfold,

1. We have designed two dynamic path planning algorithms for micro-jet considering different environmental parameters (wind speed and wind direction), those can change dynamically.
2. Different environmental parameters (wind speed, wind direction) have been set explicitly to test the battery consumption and flight duration requirement of a micro-jet, while applying two dynamic path planning techniques.
3. Comparison has been made with a baseline navigation technique to prove the effectiveness of proposed two path planning algorithms.
4. Real field deployment has been taken place to compare the proximity of the results with simulation.

We have extended the paparazziUAV [7] flight simulator to implement the path planning algorithms in a simulated environment. Five shelter points (static nodes) have been considered in the simulation. The shelter points have their GPS coordinates defined initially. Note that, in the proposed work we have considered micro-jet UAV for simulation. The micro-jet starts its journey from HOME (location from where micro-jet takeoffs) then using our proposed dynamic path planning algorithms, it traverses required shelter points at different climatic conditions used in the simulation. Finally, we have tested the proposed path planning algorithms under a real field scenario with a micro-jet UAV and observed that the performance parameters are comparable with that obtained from the simulation study. Some UAV calibration parameters like flight duration, battery voltage has been tested to provide a clear view of each condition. In a post disaster situation, it is necessary to monitor the feasibility of using UAV for damage assessment. For this kind of monitoring there must be required some important statistical data regarding to different climatic conditions. Our proposed technique is capable of providing that statistical information through simulation and effectively identifies the feasibility of using UAV as a damage assessment component in a post disaster scenario.

The rest of the paper has been organized as follows. In section 2, related works on different flight simulators and their limitations has been discussed. In section 3, our proposed path planning technique has been discussed. In section 4 simulation setup has been discussed. After simulating our proposed path planning in paparazziUAV, results have been analyzed and compared with existing navigation technique of paparazziUAV simulator in section 5. The outcome of our real deployment with micro-jet has been described and compared with simulation results in section 6. Finally, we conclude the paper in section 7.

2. RELATED WORKS

Several researches have been performed using UAVs for data acquisition, damage assessment and trajectory planning in a disaster response situation. Some routing techniques for UAVs have also been studied which can be helpful for efficient transfer of situational data in a post disaster scenario. In [3] authors provide a review of applications of UAVs for imagery collections in a disaster response situation. Here, the authors have exhibited the effectiveness of using low cost UAVs in disaster situation. In [8], Alshabatat, Abdel Ilah, et al have introduced a new routing protocol for UAVs named as Directional optimized link state routing protocol. The proposed routing has been implemented on a network simulator called OPNET [9]. The task of relaying messages between two distant ground nodes using one or more UAVs in DTN scenarios has been proposed in [10]. The proposed technique has been compared with conventional multi hop, store and forward techniques and found to be effective in terms of throughput. In [11], authors examined the techniques for data collection using UAVs from hurricane events. Due to limitations and difficulties of traditional imagery capturing techniques, the authors have proposed the use UAVs for capturing images for effective assessment of damages during hurricane. One of the challenging real emergency situations for UAVs has been presented in [12]. Here, the authors have assumed two separate legs for search & rescue of dead or injured people in any geographic area through one or more UAVs. In [13], authors have proposed two level network architecture. At level one there will be ad-hoc enabled mobile nodes. On top of that they proposed an embedded point to point back-bone network integrated with a UAV. The proposed methodology has been implemented through a network simulation named GlomoSim [14]. In [15], authors have proposed a file syncing software called pSync which precisely takes care of prioritized syncing of files in a challenged network. The proposed protocol has been tested during data transfer between information drop boxes and UAVs.

As mentioned earlier, rigorous research has been conducted using UAVs to solve different challenging issues. Though, many authors have discussed the efficiency of using UAVs as a data mule in a post disaster situation. None of the work rendered any attention on what kind of climatic condition actually accepts UAVs to fly in a post disaster situation. In a post disaster scenario as it is required to gather situational information at early stage, so there must be some pre-assessment tool capable of judging the feasibility of using UAVs in any type of disaster response situation. Besides, after any large scale disaster, it has been observed that the affected people are headed towards the shelter points of respective zones (experienced from a mock drill at Murshidabad, India during field trials of our experiments). Hence, for efficient collection of situational data there must be a dynamic path planning technique incorporated in a UAV by which it can visit required shelter points at any point of time. In our proposed technique, we have tried to solve these issues by incorporating two efficient path planning techniques in a post disaster scenario. Also we have analyzed some environmental variables and flight parameters to convey a statistical view about the feasibility of using UAV in a disaster response scenario.

3. PROPOSED PATH PLANNING TECHNIQUES

In this section, the proposed dynamic path planning techniques have been discussed. The proposed techniques have been designed on two frameworks, a) calculated shortest distance of shelter points and b) priority of shelter points at any time stamp. Based on these frameworks, we have developed two different path planning techniques suitable for efficient collection of data from shelter points of any affected zone after any large scale disaster named as MIN_ROUTE and ROUTE_PRIORITY. In a disaster response scenario, it is not only necessary to collect situational data from appropriate locations, but also it is necessary to utilize battery level
of UAV efficiently, so that it can return to HOME after traversing required shelter points. These necessities stimulated us to design two types of dynamic path planning technique suitable for disaster response situation. Note that, both techniques can be used based upon the requirement in a disaster response situation. In the next sub sections, we have discussed our two path planning techniques. Before discussing our proposed two techniques let us assume that

a) each shelter points have their GPS coordinate which is static, b) we have calculated the distances between shelter points using Haversine formula discussed in [16] and c) micro-jet has a total flight time of x minutes(say).

MIN_ROUTE technique is based upon the calculated shortest distance between shelter points. In this technique the micro-jet starts the journey from HOME location, visit the shelter points by traversing the shortest distance among them, with an objective to return HOME within x minutes covering maximum number of shelter points. If it is possible to traverse the next shelter point (Sp) at any point in the path within the flight duration, then the micro-jet moves towards that shelter point by decrementing x minutes by the time required to traverse the Sp, say Sp. minutes. Now, the micro-jet has remaining flight duration of (x-Sp) minutes, within that it would decide to go to the next possible shortest distance shelter point. It may also possible that, within remaining (x-Sp) minutes, no other shelter points can be visited. In that case, the micro-jet would return back to HOME.

If the shelter points have their priorities based on the volume of genuine situational information, then considering ROUTE_PRIORITY should be the ideal path planning technique. In this technique, priority (low to high) has been assigned to every shelter points at a particular timestamp. Considering these priority values of shelter points, micro-jet starts its journey from HOME, calculating the distance (d) of high priority node (n) with an objective to return HOME covering a distance say d'. If time required to cover the sum of the distances d and d' is less than or equal to x minutes, then only it would visit n. Otherwise it would go for next high priority node in the list and so on. Note that, here it might be possible that within the remaining flight time it is not possible for the micro-jet to visit any high priority shelter point. In that case the micro-jet would safely return back to HOME.

Note that, while designing two planning techniques, we have considered different environmental parameters like wind speed, wind direction, etc. that may change dynamically. The speed and battery level of the micro-jet might also vary based upon the environmental parameters. The algorithms proposed for path planning technique have been discussed as follows.

Algorithm 1. Calling of appropriate path planning technique

1. Start
2. Function set_flag (flag)
   2.1 if flag=0 then 2.1.1 call MIN_ROUTE ()
   2.2 else 2.2.1 call ROUTE_PRIORITY ()
3. End

Algorithm 2. Calculation of remaining flight time

1. Start
2. Function fl_time (Ws, W0, S, D)
   2.1 Set Xrem = x
   7.2 return Xrem in minutes
3. End

Algorithm 3. Calculation of fl_dist function to each shelter point

1. Start
2. Function fl_dist (dS, n, dS, Xrem, S)
   2.1 if (dS+dS)/S) ≤ Xrem, then 2.1.1 return true
   2.2 else 2.2.1 return false
3. End

Algorithm 4. Design of MIN_ROUTE ()

1. Start
2. Call set_flag (0)
3. Set = HOME
4. Set i = HOME
5. Calculate distance vector j from i
6. Arrange each node in ascending order of their distance
7. For each node in j do
   7.1 select node n with shortest distance from i
   7.2 if call fl_dist (dS, n, dS, fl_time (Ws, W0, S, D), S) = true then
      7.2.1 move towards shelter point n
      7.2.2 set i=n
      7.2.3 Go to step 4
   7.3 else
      7.3.1 increment j to 1
      7.3.2 Go to step 6.2
8. Exit

Algorithm 5. Design of ROUTE_PRIORITY ()

1. Start
2. Call set_flag (1)
3. Set i = HOME
4. Prepare priority list p of shelter points excluding HOME at timestamp t
5. Assign the priorities in ascending order
6. Calculate distance vector j from i
7. For each node in p do
   7.1 select node n
   7.2 if call fl_dist (dS, n, dS, fl_time (Ws, W0, S, D), S) = true then
      7.2.1 move towards shelter point n
      7.2.2 set i=n
      7.2.3 Go to step 6
   7.3 else
      7.3.1 Find out next shelter point which has the highest priority.
      7.3.2 Go to step 6
8. Exit
The above algorithms demonstrate the working process of the proposed dynamic path planning techniques. A flag bit has been used for efficient switching between these two techniques (see Algorithm 1). The function \texttt{fl\_time} has been used to calculate the remaining flight time by considering different arguments (see Algorithm 2). The function \texttt{ft\_dist} has been calculated to predict whether the micro-jet can traverse to any shelter point within remaining flight time or not (see Algorithm 3). In Algorithm 4 and 5 two path-planning techniques have been discussed. The notations used in the algorithms have been discussed in Table 1.

### Table 1: Notations used for designing Algorithms

<table>
<thead>
<tr>
<th>Notation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>set_flag ()</td>
<td>A function that decides which path planning technique will be executed</td>
</tr>
<tr>
<td>Flag</td>
<td>Flag bit has been used as an argument of set_flag(). Flag bit has been initialized by 1 or 0.</td>
</tr>
<tr>
<td>W_s</td>
<td>Changing wind speed of the environment in km/h</td>
</tr>
<tr>
<td>W_d</td>
<td>Changing wind direction of the environment in degree.</td>
</tr>
<tr>
<td>S</td>
<td>Varying speed of micro-jet in km/h</td>
</tr>
<tr>
<td>D</td>
<td>Distance covered by micro-jet in unit.</td>
</tr>
<tr>
<td>X_{rem}</td>
<td>Remaining flight time of micro-jet in minutes.</td>
</tr>
<tr>
<td>HOME</td>
<td>Node from where micro-jet takeoffs.</td>
</tr>
<tr>
<td>d_{ij}</td>
<td>Calculated distance of any shelter point j from shelter point i (i\neq j).</td>
</tr>
<tr>
<td>d_{H}</td>
<td>Calculated distance from node i to HOME.</td>
</tr>
</tbody>
</table>

As mentioned earlier, these proposed path planning techniques have been designed and implemented by considering a) different dynamically changing environmental conditions, b) varying speed of micro-jet and c) distance of micro-jet from the Shelter points. We have implemented these techniques on paparazziUAV flight simulator considering above cases. In next section the simulation setup for implementation of the proposed technique has been discussed.

### 4. EXPERIMENTAL SETUP

As discussed in section 1, the proposed path planning technique has been implemented in paparazziUAV flight simulator. Note that, in this work we have extended the existing navigation algorithm for micro-jet in paparazziUAV to implement our proposed technique. Figure 1 & 2 shows the graph consisting of five shelter points (S\textsubscript{i}) (i in 1 to 5) and HOME node while implementing MIN\_ROUTE and ROUTE\_PRIORITY techniques. There are bidirectional edges between each shelter points and HOME nodes as represented in graphs. Weight has been assigned to each edge which is the calculated distance between the shelter points including HOME. Initial priority has been defined to each shelter point while implementing ROUTE\_PRIORITY technique (Figure 2). Note that, for each path planning technique one test case has been considered here. There might be other test cases based on varying distances and priorities of shelter points. It can also be observed from Figure 1 & 2, paths have been obtained while performing the simulation for each technique. The path obtained for MIN\_ROUTE is (HOME, S5, S1, S2, S3, S4, HOME). For ROUTE\_PRIORITY the path obtained as (HOME, S3, S1, S2, S5, S4, HOME).

### 4.1 Simulation Setup

In this section we have discuss our paparazziUAV setup that has been taken into account while implementing our proposed path planning techniques. The details about simulation setup have been discussed in Table 2.

![Graph consisting of five shelter points with distances between shelter points including HOME in MIN\_ROUTE technique.](image1.png)

![Graph consisting of five shelter point with distances between shelter points and priority of shelter points have been assigned for implementing ROUTE\_PRIORITY.](image2.png)

| Table 2: Simulation setup for implementing proposed path planning in paparazziUAV. |
|---------------------------------|---------------------------------|
| Total simulation time           | 2 hours                         |
| Total area considered           | 11 square kilometer             |
| Number of shelter points considered | Five                          |
| Number of HOME locations        | 1                              |
| Type of UAV used                | Micro-jet                      |
| Environmental parameter (Dynamically changing during simulation) | Wind speed, Wind direction |
| Calibration parameters (Varying during simulation) | Speed, Distance, Flight time |
| Initial battery level           | 12.5 volt                      |
Based on the above mentioned simulation parameters the proposed path planning techniques have been executed in paparazziUAV. Figure 2 to 4 shows some snapshots of run time environment of the simulation while implementing the proposed techniques.

5. RESULTS & ANALYSIS

In this section, the results of applying the proposed path planning techniques have been discussed in details. Furthermore, the proposed methodologies have been compared with baseline navigation technique for micro-jet UAV in terms of calibration parameters like flight duration and battery level. Both the proposed work and baseline technique have been simulated with explicitly provided wind speed (km/h) and a constant wind direction for effective analysis and comparison. Twenty different simulations (ten for each technique) have been executed considering five different wind speed threshold values. The wind speed threshold values considered are 7.2 km/h, 14.4 km/h, 21.6km/h and 28.8 km/h. The wind direction has been considered which is 360°NE. Not that, in our simulation, wind speed of 0 km/h has been considered. This means that, in that case we are not explicitly specifying the wind speed of the environment rather letting the simulation to decide itself the “default” wind speed value. From Figure 6, it can be observed that different variations of wind speed might affect the flight time of the UAV, while implementing the proposed path planning techniques. Some interesting behavior of the system has also been observed. At default wind speed (i.e. at 0 km/h) the micro-jet is taking about 4.18 minutes to cover the shelter points using MIN_ROUTE. Whereas, in ROUTE_PRIORITY it takes only 3.5 minutes. It can be concluded from Figure 6 that ROUTE_PRIORITY and MIN_ROUTE gives satisfactory results in terms of average flight duration. It can be noticed from Figure 6 that, for different wind speed threshold values, the two proposed techniques behave differently. This is because of the location of the shelter points that need to be covered for the two cases. In a disaster response scenario, it may so happen that the shelter points are scattered in different places. So, the micro-jet has to move for the wind direction or again the wind direction from time to time. Due to the same reason, it has also been observed from Figure 7, in terms of battery power consumptions, MIN_ROUTE gives better result than ROUTE_PRIORITY. It has been tested during simulation that maximum wind speed can be about 29 km/h in which the micro-jet can fly. Beyond that threshold micro-jet is not capable to fly anymore. It can also have been concluded from Figure 7 that battery power consumption is high at approx. 29 km/h wind speed due to high speed rotation of the motors.
The feasibility of deploying micro-jet at different disaster scenarios has been studied. It can be observed from Figure 8 & 9 that battery level fluctuation happens more frequently in ROUTE_PRIORITY than MIN_ROUTE. Two techniques take moderately low average flight duration and battery level to cover the shelter points. It has been observed that ROUTE_PRIORITY and MIN_ROUTE techniques take average flight duration of 4.86 and 4.79 minutes. Whereas, the baseline algorithm takes an average of 6.08 minutes to cover the shelter points. This is because, in Baseline technique, micro-jet simply traversing the shelter point without knowing any prior knowledge about them. In our proposed cases, we have assigned importance to the shelter points based on calculated shortest distance and priority. Also the proposed techniques consume less battery power than baseline technique (see Figure 11). It has been observed that, average battery power consumption for MIN_ROUTE and ROUTE_PRIORITY are 1.7 and 1.54 volts respectively. Whereas, the baseline navigation technique consumes an average of 2.12 volts of battery power. Hence, from these observations it can be concluded that our proposed methodology not only achieves better performance in terms of some calibration parameters but also it provides some statistical data for micro-jet which might be helpful to study the feasibility of deploying micro-jet in a post disaster scenario.

Next, comparison between proposed dynamic path planning technique and baseline technique of paparazziUAV has been discussed. It can be observed from Figure 10 & 11 that proposed two techniques take moderately low average flight duration and battery level to cover the shelter points. It has been observed that ROUTE_PRIORITY and MIN_ROUTE techniques take average flight duration of 4.86 and 4.79 minutes. Whereas, the baseline algorithm takes an average of 6.08 minutes to cover the shelter points. This is because, in Baseline technique, micro-jet simply traversing the shelter point without knowing any prior knowledge about them. In our proposed cases, we have assigned importance to the shelter points based on calculated shortest distance and priority. Also the proposed techniques consume less battery power than baseline technique (see Figure 11). It has been observed that, average battery power consumption for MIN_ROUTE and ROUTE_PRIORITY are 1.7 and 1.54 volts respectively. Whereas, the baseline navigation technique consumes an average of 2.12 volts of battery power. Hence, from these observations it can be concluded that our proposed methodology not only achieves better performance in terms of some calibration parameters but also it provides some statistical data for micro-jet which might be helpful to study the feasibility of deploying micro-jet in a post disaster scenario.
Figure 11: Comparison of MIN_ROUTE, ROUTE_PRIORITY with respect to Baseline navigation technique in terms of battery power consumption varying different wind speed threshold.

6. FIELD EXPERIMENT & ANALYSIS

We have tested our proposed path planning techniques during field deployment and compared the results with simulation results. We have designed a micro-jet prototype model that has been used during the field deployment. The detail specifications used during the field deployment with the prototype model have been shown in Table 3. The proposed prototype model is capable of providing around 14 to 15 minutes of flight time.

Table 3: Specification of developed micro-jet prototype used during deployment

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS count</td>
<td>7</td>
</tr>
<tr>
<td>Flight mode</td>
<td>Fully autonomous</td>
</tr>
<tr>
<td>Total weight of the prototype</td>
<td>1.3 kg</td>
</tr>
<tr>
<td>Maximum thrust</td>
<td>1.5 kg</td>
</tr>
<tr>
<td>Initial battery level</td>
<td>16.5 v</td>
</tr>
<tr>
<td>Propeller size</td>
<td>17.5 inch</td>
</tr>
<tr>
<td>Motor</td>
<td>5010 brushless</td>
</tr>
<tr>
<td>Battery</td>
<td>4s Lipo, 3000 MH</td>
</tr>
</tbody>
</table>

After the execution of the path planning techniques in simulation, we have obtained an optimal path for each case (discussed in section 4). During the field deployment those obtained paths have been considered as the navigation routes for micro-jet. Five shelter points have been considered, the distance between the shelter points has been specified, similar to that was designed during the simulation. The micro-jet starts its journey, then using the route obtained from MIN_ROUTE and ROUTE_PRIORITY, it visits the shelter points and returns back to HOME. While visiting the shelter points, the altitude has been specified to 180 to 200 meter from the ground. The wind speed was around 25 to 30 km/h. Note that, here we have tested our proposed algorithms by slightly adjusting the directions of the wind, so that we might achieve the wind direction of 360° NE. The system has been tested in terms of flight duration and battery level requirements, so that the results obtained from simulation can be compared with the field trial. From Table 4 it can be observed that, our proposed methodologies give proximate results compared to simulation results. It can be observed from Table 4 that at 25 to 30 km/h wind speed micro-jet takes 5.50 minutes and 5 minutes flight duration during field trial test for MIN_ROUTE and ROUTE_PRIORITY respectively. Whereas, it took around 5 minutes for the two algorithms in simulated environment. In terms of battery power, micro-jet consumes 2.1 volt and 2.4 volt of battery power during field trial test for MIN_ROUTE and ROUTE_PRIORITY respectively. Whereas, it consumed 2.1 volt of battery power for MIN_ROUTE and 1.7 volt of battery power for ROUTE_PRIORITY in the simulated case study. These results clearly show the significant achievement of the proposed work. Hence, from these observations, it can be concluded that the proposed work is capable of generating some statistical data with respect to different environmental and physical parameters, which might be helpful for the real deployment of micro-jet in a post disaster scenario and also it is quite effective to dynamically plan the roots of a UAV.

Table 4: Results of field deployment and simulation at wind speed 25 to 30 km/h

<table>
<thead>
<tr>
<th>Test Mode</th>
<th>Flight duration (MIN_ROUTE)</th>
<th>Flight duration (ROUTE_PRIORITY)</th>
<th>Battery level consumption (MIN_ROUTE)</th>
<th>Battery level consumption (ROUTE_PRIORITY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field test</td>
<td>5.50 minutes</td>
<td>5 minutes</td>
<td>2.1 volt</td>
<td>2.4 volt</td>
</tr>
<tr>
<td>Simulation</td>
<td>5 minutes</td>
<td>5 minutes</td>
<td>2.1 volt</td>
<td>1.7 volt</td>
</tr>
</tbody>
</table>

7. CONCLUSION

In this paper, the flight of a UAV has been tested in paparazziUAV simulator through implementing two dynamic path planning methodologies in post disaster situations. Different calibration parameters have been tested with varying wind speed and wind directions to generate some statistical data which might be effective to fly the UAV in a post disaster situation. Though this kind of statistical data, one can efficiently calculate the feasibility of using UAV in post disaster situations. However, here we have only considered micro-jet for simulation. In our future work we thought about the implementation of our proposed path planning in rotorcraft by considering some more calibration parameters like altitude, temperature, wind pressure etc.

8. REFERENCES


