Routing of Unmanned Aerial Vehicles for Search and Rescue Operations: A Case Study in Oman

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Abstract

The use of unmanned aerial vehicles (UAVs) in disaster search and rescue operations has become increasingly prevalent due to their potential to quickly and effectively search for missing persons using onboard sensors and cameras. This study addresses the problem of routing a UAV to search a designated area following an emergency call reporting a missing person. The objective is to minimize the expected time to locate the individual. To achieve this, the search area is divided into grids, each representing the area the UAV can scan in a single pass from a specific altitude. Each grid is assigned a probability of containing the target based on geographic features such as mountains, roads, plains, and the last known location of the missing person. We developed a mathematical programming formulation for the problem, which was implemented in IBM ILOG CPLEX Optimization Studio. However, our tests revealed that solving the problem using this method was not feasible within reasonable time limits due to the problem's size and its exponential growth as the target region expands. Consequently, we developed several alternative construction algorithms. The solutions obtained from these algorithms were further improved using a tabu search algorithm. These algorithms were evaluated across various test instances for solution quality and computational efficiency. The results demonstrate that the developed algorithms significantly reduced the time required to solve the problem and improved the effectiveness of UAVs in disaster search and rescue missions. Additionally, we conducted a case study in Oman focused on locating individuals missing while hiking. This study presents a novel and practical approach for UAV routing in search and rescue operations and provides a solid foundation for future research.

Keywords
UAV, Search and Rescue, Routing, Mathematical Programming, Heuristics.

Biographies
Hakan Gultekin is an Associate Professor in the Department of Mechanical and Industrial Engineering at Sultan Qaboos University, Muscat, Oman. He earned his B.Sc, M.Sc, and Ph.D. in Industrial Engineering from Bilkent University, Türkiye, and completed his Post-Doctoral Fellowship at the University of Liege, Belgium. He has received various awards and recognition, including the Best Teacher Award in 2023, Project Performance Awards in 2015 and 2019, and the Young Researcher Career Development Award from the Scientific and Technological Research Council of Türkiye. He is a member of several professional societies, including the Industrial Engineering and Operations

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Abdulkadir Gultekin is a BSc student in the Department of Industrial Engineering at Middle East Technical University, Ankara, Türkiye. His research interests are applied optimization, algorithm development and artificial intelligence.