

Unmanned Aerial Vehicle Applications for Highway Transportation

Identification of research (2006–present) focusing on autonomous micro unmanned aerial vehicles (UAVs) for transportation applications, including the examination of other industries that may also utilize micro UAVs.

TOPIC

Reference Results

Hovering, Intelligence, Monitoring, Reconnaissance, Surveillance, and Tracking

HAWK: An unmanned mini helicopter-based aerial wireless kit for localization

Author(s): Liu, Zhongli;¹ Chen, Yinjie;¹ Liu, Benyuan;¹ Cao, Chengyu;² Fu, Xinwen¹

Year: 2012

Source: Proceedings—IEEE INFOCOM, pp. 2219–2227

Publisher: IEEE Computer Society

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The authors present a fully functional and highly portable mini UAV system, HAWK, for conducting aerial localization. HAWK is a programmable mini helicopter, Draganflyer X6, armed with a wireless sniffer, Nokia N900. The authors developed custom proportional-integral control laws to implement a robust waypoint algorithm for the mini helicopter to fly a planned route. A Moore space-filling curve was designed as a flight route for HAWK to survey a specific area. A set of theorems was derived to calculate the minimum Moore curve level for sensing all targets in the area with minimum flight distance. With such a flight strategy, the authors confined the location of a target of interest to a small hot area. The authors recursively applied the Moore curve-based flight route to the hot area for a fine-grained localization of a target of interest; therefore, HAWK did not rely on a positioning infrastructure for localization. The authors have conducted extensive experiments to validate the feasibility of HAWK and their theory.



Routing for continuous monitoring by multiple micro UAVs in disaster scenarios

Author(s): Mersheeva, Vera;¹ Friedrich, Gerhard¹

Year: 2012

Source: ECAI 2012: 20th European Conference on Artificial Intelligence, pp. 588–593

Publisher: IOS Press

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<http://www.uni-klu.ac.at/main/inhalt/1.htm>

In a disaster situation, a quickly obtained and regularly updated overview image of an area provides essential information for rescue mission planning. Such an overview image can be composed from the individual pictures taken by a fleet of UAVs; however, at present, drones are remotely controlled by humans during such missions. To the best of the authors' knowledge, no research has been conducted on the problem of UAV routing for such a task; therefore, the authors propose a method based on the well-known metaheuristic Variable Neighborhood Search. In particular, the authors developed two new heuristics to construct the initial solution and an additional neighborhood operator. Computational experiments indicate that solutions obtained by the authors' metaheuristic do not exceed the optimum by more than 26.9 percent on small scenarios. For the large instances with hundreds of points (in which no optimal solution is known), the proposed method constructs feasible solutions in less than 1 second. (Reprinted from *ECAI 2012: 20th European Conference on Artificial Intelligence*, L. De Raedt, C. Bessiere, and D. Dubois (Eds.), "Routing for Continuous Monitoring by Multiple Micro UAVs in Disaster Scenarios," pp. 588–593, Copyright (2012), with permission from IOS Press)

Route planning algorithms for UAVs with refueling constraints

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Year: 2012

Source: Proceedings of the American Control Conference, pp. 3266–3271

Publisher: IEEE Computer Society

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Small UAVs are currently used in several monitoring applications to monitor a set of targets and to collect relevant data. One of the main constraints that characterize a small UAV is the maximum amount of fuel the vehicle can carry. In this article, the authors consider a single UAV routing problem in which there are multiple depots, and the vehicle is allowed to refuel at any one of them. The objective of the problem

is to find a path for the UAV such that each target is visited at least once by the vehicle, the fuel constraint is never violated along the path for the UAV, and the total cost of the edges present in the path is a minimum. The authors first developed a mixed-integer, linear programming formulation to solve the problem optimally. The authors propose fast and efficient construction and improvement heuristics to solve the same. Computational results are also presented to corroborate the solution quality and the running times of all the algorithms.

Implementation of an onboard visual tracking system with small UAVs

Author(s): Qadir, Ashraf;¹ Semke, William;¹ Neubert, Jeremiah¹

Year: 2011

Source: International Journal of Innovative Technology and Creative Engineering, vol. 1, no. 10, pp. 17-25

Author affiliation:

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<http://www.ndsu.edu/me/>

The authors present a visual tracking system that is capable of running in real time on board a small UAV. The tracking system is computationally efficient and invariant to lighting changes and rotation of the object or the camera. Detection and tracking are autonomously conducted on the payload computer, and there are two different methods for creation of the image patches. The first method starts detecting and tracking by using a stored image patch that was created prior to flight with previous flight data. The second method allows the operator on the ground to select the interest object for the UAV to track. The tracking system is capable of redetecting the object of interest in the event of tracking failure. Performance of the tracking system was verified both in the lab and during actual flights of the UAV. Results show that the system can run on board and track a diverse set of objects in real time.

Analysis of UAVs concept of operations in ITS applications

Author(s): Gebre-Egziabher, Demonz;¹ Xing, Zhiqiang¹

Year: 2011

Source: CTS Project No. 2008023, Final report, p. 43

Publisher: Intelligent Transportation Systems Institute, University of Minnesota

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<http://www.cts.umn.edu/>

The authors developed a framework for the design of concept of operations (CONOP) that uses small uninhabited aerial systems (SUAS) to support intelligent transportation systems application of highway and transportation infrastructure monitoring. In such envisioned applications, these vehicles will be used for tasks such as remote collection

of traffic data or inspection of roads and bridges. As such, a risk that has to be managed for these applications is that of vehicle–infrastructure collision. Various solutions to ensure safe separation between the UAV and the object being inspected have been proposed; however, most, if not all, of these solutions rely on a multisensor approach, which combines digital maps of the infrastructure being inspected with an integrated Global Positioning System/inertial navigator. Although “turn-key” solutions for such multisensor systems exist, the performance specifications provided by their manufactures do not provide sufficient information to allow precisely quantifying or bounding the collision risk. Furthermore, size, weight, and power constraints posed by these small aerial vehicles limit the use of redundant hardware and software as a risk-mitigation strategy. The purpose of the work reported here was to develop a framework for the design of CONOPs that takes these SUAS limitations into account. The method outlined shows, in part, how these vehicle–infrastructure collision risks can be estimated or conservatively bounded.

Development of a small UAV with real-time video surveillance

Author(s): Nam, Changho¹; Danielson, Scott¹

Year: 2011

Source: ASEE Annual Conference and Exposition, Conference Proceedings

Publisher: American Society for Engineering Education

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The authors describe a capstone project, the objective of which was to design, build, and successfully test a UAV with real-time video surveillance capabilities. The student team was composed of seven students within an aeronautical concentration of their mechanical engineering technology program. The students designed and built a UAV capable of flying under direct manual control and indirect automatic control. Direct manual control was accomplished via a model radio-control transmitter, whereas indirect control was accomplished via the onboard autopilot system. Programmable autonomous flight software, utilizing global positioning satellites, controls the autopilot system. A ground control station (GCS) sends and receives telemetry from a 2.4-GHz modem located in the UAV. The GCS utilized Paparazzi, an open-source hardware and software autopilot platform that allows mission-specific flight plans to be created, uploaded, executed, and monitored during the UAV’s flight. Real-time video from the UAV is transmitted to the GCS via an antenna and receiver. This comprehensive design–build project, concluding with successful test flights, enhanced student learning and performance during the course of the project. The authors provide assessment data gathered by the project faculty mentor.

Use of micro UAVs in roadside condition surveys

Author(s): Hart, W. Scott;¹ Gharaibeh, Nasir G.¹

Year: 2011

Source: T and DI Congress 2011: Integrated Transportation and Development for a Better Tomorrow—Proceedings of the 1st Congress of the Transportation and Development Institute of ASCE, pp. 80–92

Publisher: American Society of Civil Engineers

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<https://www.civil.tamu.edu/>

Micro UAVs that are equipped with digital imaging systems and global positioning systems provide a potential opportunity for improving the effectiveness and safety of roadside condition and inventory surveys. The authors provide an assessment of the effectiveness of micro UAVs as a tool for collecting condition and inventory data for roadside infrastructure assets by conducting a field experiment. The field experiment entailed performing a level-of-service condition assessment on 10 roadway sample units on IH-20 in Tyler, TX. The condition of these sample units was assessed twice: onsite (i.e., ground truth) and by observing digital images (still and video) collected via a micro UAV. The results of these surveys were analyzed to determine if there were statistically significant differences in the standard deviation and mean values of the condition ratings. In addition, the operational performance of the micro UAV was observed in various weather and field conditions. The results of this study will help transportation agencies to decide whether micro UAV technology can be adopted for inventory and condition surveys of roadside assets and maintenance activities.

Small unmanned aircraft evaluated for avalanche control

Author(s): McCormack, Edward;¹ Stimberis, John²

Year: 2010

Source: Transportation Research Record, no. 2169, pp. 168–173

Publisher: Transportation Research Board

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The Washington State Department of Transportation's (DOT) snow avalanche control program reduces winter roadway closure times and hazards to motorists. The University of Washington and the Washington State DOT evaluated small unmanned aircraft systems (UASs) as a tool to enhance this program. Because of military investment, UAS technology has dropped in cost as it has become increasingly capable

and easier to operate. Commercially available UASs, which fly autonomously, can be operated off a roadway and can collect low-cost, real-time aerial imagery while also carrying payloads. The authors conducted a series of test flights involving both fixed- and rotary-wing (i.e., helicopter) UASs over a roadway in mountainous terrain. The flights demonstrated that UASs can conduct snowpack and terrain surveillance and can accurately drop explosive charges, such as those used to trigger controlled avalanches. The rotary-wing UAS was particularly usable because of its ability to hover, which provided a stable camera platform, and because it required minimal area to land. The reliability of UASs is a concern, and their capabilities may be challenged by mountainous terrain and weather. This problem may be reduced as UASs become either less expensive and more expendable or more reliable and all-weather capable. A major barrier to use of UASs is the need to obtain approval to fly from the Federal Aviation Administration (FAA), a process that can be time-consuming and restrictive. FAA is currently updating its plans to integrate UASs into the national airspace, and a number of technology-based solutions are being considered.

Autopilots for small UAV: A survey

Author(s): Chao, Haiyang;¹ Cao, Yongcan;¹ Chen, Yangquan¹

Year: 2010

Source: International Journal of Control, Automation and Systems, vol. 8, no. 1, pp. 36-44

Publisher: Springer Verlag

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The authors present a survey of the autopilot systems for small or micro UAVs. The objective of the study is to provide a summary of the current commercial, open-source, and research autopilot systems for convenience of potential small UAV users. The UAV flight control basics are introduced first. The radio control system and autopilot control system are then explained from both the hardware and software viewpoints. The authors compare several typical off-the-shelf autopilot packages in terms of sensor packages, observation approaches, and controller strengths, and introduce some open-source autopilot systems. The authors' conclusion includes a summary of the current autopilot market and a remark on future development.

Autonomous feature following for visual surveillance using a small UAV with gimbaled camera system

Author(s): Lee, Deok-Jin;¹ Kaminer, Isaac;² Dobrokhodov, Vladimir;² Jones, Kevin²

Year: 2010

Source: International Journal of Control, Automation and Systems, vol. 8, no. 5, pp. 957–966

Publisher: Springer Verlag

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<http://www.nps.edu/Academics/GSEAS/MAE/Index.asp>

The authors present the development of feature-following-control and distributed-navigation algorithms for visual surveillance through the use of a small UAV equipped with a low-cost imaging sensor unit. The authors developed an efficient map-based feature-generation-and-following-control algorithm to make an onboard imaging sensor track a target. An efficient navigation system was also designed for real-time position and velocity estimates of the unmanned aircraft, which were used as inputs for the path-following controller. The authors demonstrated the performance of the proposed autonomous path-following capability with a stabilized gimbaled camera onboard a small unmanned aerial robot through flight tests with application to target tracking for real-time visual surveillance.

A hybrid micro aerial vehicle for ingress and egress of urban environments

Author(s): Green, William E.;¹ Oh, Paul Y.²

Year: 2009

Source: IEEE Transactions on Robotics, vol. 25, no. 2, pp. 253–263

Publisher: IEEE Computer Society

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Small bird-sized aerial robots are expendable and can fly over obstacles and through small openings to assist in the acquisition and distribution of intelligence during reconnaissance, surveillance, and search-and-rescue missions in urban environments; however, limited flying space and densely populated obstacle fields require a vehicle that is capable of hovering but is also maneuverable. The researchers incorporated a secondary flight mode into a fixed-wing aircraft to preserve its maneuverability while

adding the capability of hovering. An inertial measurement sensor and an onboard flight control system were interfaced and used to transition the hybrid prototype from cruise to hover flight and to sustain a hover autonomously. Furthermore, the hovering flight mode was used to maneuver the aircraft through small openings, such as doorways. An ultrasonic and infrared sensor suite was designed to follow exterior building walls until an ingress route was detected. Reactive control was then used to traverse the doorway and to gather reconnaissance. The authors describe the holistic approach of platform development, sensor suite design, and control of the hybrid prototype.

Using color profiles for street detection in low-altitude UAV video

Author(s): Candamo, J.,¹ Kasturi, R.,¹ Goldgof, D.¹

Year: 2009

Source: Proceedings of SPIE—The International Society for Optical Engineering, vol. 7307

Publisher: SPIE

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<http://www.cse.usf.edu/>

The authors describe a vision-based, street-detection algorithm to be used by small autonomous aircraft in low-altitude urban surveillance. The algorithm uses Bayesian analysis to differentiate between street and background pixels. The color profile of edges on the detected street is used to represent objects with respect to their surroundings. These color profiles are used to improve street detection over time. Pixels that do not likely originate from the “true” street are excluded from the recurring Bayesian estimation in the video. The authors present results that compare to a previously published UAV road detection algorithm. Robust performance is demonstrated with urban surveillance scenes, including UAV surveillance, police chases from helicopters, and traffic monitoring. The authors show that the proposed method is robust to data uncertainty and has low sensitivity to the training dataset. The authors computed performance by using a challenging multisite dataset that included compression artifacts, poor resolution, and large variation of scene complexity.

Vision-based surveillance system using low-cost UAV

Author(s): Kim, Jonghun;¹ Lee, Daewoo;¹ Cho, Kyeumrae;¹ Jo, Seonyong;¹ Kim, Jungho;¹ Han, Dongin¹

Year: 2009

Source: Intelligent Vehicle Controls and Intelligent Transportation Systems—Proceedings of the 3rd International Workshop—IVC and ITS 2009 in Conjunction with ICINCO 2009, pp. 143–148

Publisher: INSTICC Press

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http://aerospace.ae.pusan.ac.kr/html_e/01_01_p_part.php

The authors describe the development of a surveillance system in the laboratory for small UAVs. This system is important equipment in a mission-oriented UAV. To perform well on search, this system can track images and take three-dimensional (3-D) measurements of a target, as well as acquire high-quality images. Image tracking is carried out by the Kaiman filter. The position of the target in an image and the relationship among the coordinate systems of the UAV and the camera and reference are used to solve the 3-D position of the target in real coordinates. The authors present the hardware system, as well as the algorithm for the electro-optical system, and verify the performance of the image tracking and real-time 3-D measurement of a target's position. In particular, linear parameter varying was applied to the measurement system to reduce the 3-D measurement error of the target. The authors present the performances of the algorithms in figures.

Exploring transportation applications of small unmanned aircraft

Author(s): McCormack, Edward^{1,2}

Year: 2009

Source: ITE Journal, vol. 79, no. 12, pp. 32–36

Publisher: Institute of Transportation Engineers

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<http://www.ce.wsu.edu/index.html>

UAVs have the potential to be used for traffic and transportation organizations—they are cost-effective and can be equipped with cameras that provide useful information for transportation agencies. The UAV technology can also be useful for a range of maintenance, planning, and operations functions. Potential uses of UAVs include crash scene photography, surveying, security inspections, construction data collection, and monitoring the condition and congestion of roadways. The author reports the results of two types of tests conducted by the University of Washington and the Washington State Department of Transportation to evaluate the technical capabilities of UAVs and explores institutional concerns associated with their potential use.

Detecting and counting vehicles from small low-cost UAV images

Author(s): Cheng, Penggen;¹ Zhou, Guoqing;^{1,2} Zheng, Zezhong^{2,3}

Year: 2009

Source: American Society for Photogrammetry and Remote Sensing Annual Conference 2009, ASPRS 2009, vol. 1, pp. 138-144

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In recent years, many civil users have been interested in UAVs for traffic monitoring and traffic data collection, because they have the ability to cover a large area, focus resources on current problems, travel at higher speeds than can ground vehicles, and they are not restricted to traveling on the road network. The authors present a method for detecting and counting vehicles from UAV video flow. The objective of the research is to monitor activities at traffic intersections for detecting congestions and then predict the traffic flow. The algorithm for vision-based detection and counting of vehicles in monocular image sequences for traffic scenes was developed. In the algorithm, video frame-to-frame matching to track a vehicle is one of the important steps. Dynamic vehicles are identified by using both background elimination and background registration techniques. The background elimination method uses the concept of least squares to compare the accuracies of the current algorithm with the already existing algorithms. The background registration method uses background subtraction, which improves the adaptive background mixture model and makes the system learn faster and more accurately, and adapts effectively to changing environments. In addition, because of high data-sampling rates of video flow, the authors also analyzed and discussed the resampling of video flow.

Airborne communication networks for small unmanned aircraft systems

Author(s): Frew, Eric W.¹ Brown, Timothy X.²

Year: 2008

Source: Proceedings of the IEEE, vol. 96, no. 12, pp. 2008-2027

Publisher: IEEE Computer Society

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The authors explore the role of meshed airborne communication networks in the operational performance of small unmanned aircraft systems. Small unmanned aircraft systems have the potential to create new applications and markets in civil domains, enable many disruptive technologies, and put considerable stress on air traffic control systems. The authors argue that, of the existing networked communication architectures, only meshed ad hoc networking can meet the communication demands for the large number of small aircraft expected to be deployed in future. The authors present experimental results using the Heterogeneous Unmanned Aircraft System to show that meshed airborne communication is feasible, that it extends the operational envelope of small unmanned aircraft at the expense of increased communication variability, and that net-centric operation of multiple cooperating aircraft is possible. In addition, the authors discuss the ability of airborne networks of small unmanned aircraft to exploit controlled mobility to improve performance.

The use of small unmanned aircraft by the Washington State Department of Transportation

Author(s): McCormack, Edward D.¹

Year: 2008

Source: Research Report

Publisher: Washington State Department of Transportation

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<http://depts.washington.edu/trac/>

Small UAVs are increasingly affordable and easy to transport and launch, and they can be equipped with cameras that provide information that is usable for transportation agencies. The Washington State Department of Transportation (WSDOT) conducted a series of UAV tests to evaluate their capabilities while also exploring institutional issues. These tests, while exploring the general capabilities of UAVs, focused on

evaluating the use of a UAV as an avalanche control tool on mountain slopes above State highways. WSDOT's maintenance division has an active snow avalanche control program that is designed to reduce highway closure time and hazards to motorists, and the use of UAVs was seen as having some potential operational advantages. The UAVs also captured aerial images suitable for traffic surveillance and data collection. The evaluation found that the main limitation to UAV use is institutional, particularly the need to obtain approval to fly from the Federal Aviation Administration (FAA). This approval process will make UAV use a challenge, but these issues may change as the FAA considers new rules.

Remotely Piloted Vehicles/UAV surveillance for transportation management and security

Author(s): Gebre-Egziabher, Demoz¹

Year: 2008

Source: Final Report, p. 37

Publisher: Intelligent Transportation Systems Institute, University of Minnesota

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<http://www.cts.umn.edu/>

The author describes the results of an investigation into some of the technical and operational issues associated with using unmanned aerial systems (UAS) for the application of surveillance in support of transportation infrastructure management and security. As part of this investigation, the researcher developed a low-cost, miniature, hand-launched aerial vehicle and supporting ground systems suitable for surveillance of highways and traffic infrastructure. Except for the ground station software, this system was built from off-the-shelf components. The ground station software developed was used to enhance ground station operators' situational awareness and simultaneously allowed analysis of the data transmitted from the aerial vehicle. In addition, a key system that was developed was an open-source guidance, navigation, and control software suite for autonomous operation of small aerial vehicles. This work culminated in a series of flight tests in which the UAS developed was used as a tool to enhance situational awareness over a simulated traffic incident or emergency situation. The test consisted of defining a series of waypoints around the area of the simulated incident and launching the miniature aerial vehicle to autonomously fly from waypoint to waypoint.

An autonomous palm-sized gliding micro air vehicle

Author(s): Wood, Robert J.;¹ Avadhanula, S.;² Steltz, E.;² Seeman, M.;² Entwistle, J.;² Bachrach, A.;² Barrows, G.;³ Sanders, S.;² Fear, R. S.²

Year: 2007

Source: IEEE Robotics and Automation Magazine, vol. 14, no. 2, pp. 82–91

Publisher: IEEE Computer Society

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The authors discuss the development of a set of core technologies that are key to the realization of an autonomous 2-g glider. Two aspects of development that the authors do not discuss in detail are the low cost and ease of constructing an individual MicroGlider. Integration of the core technologies is simplified through a number of rapid prototyping techniques, and the low cost of most components allows for rigorous testing to be done without the worry of substantial damage to the glider.

Low-cost compact instrumentation, control, and aerial surveillance payload support for small UAVs

Author(s): Bird, John;^{1,2,3} Culhane, Andrew;^{1,2} Sharkasi, Adam;^{1,2} Kochersberger, Kevin^{1,3,4}

Year: 2007

Source: Collection of Technical Papers—2007 AIAA InfoTech at Aerospace Conference, vol. 1, pp. 413–422

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Applications of aerial surveillance include homeland security, law enforcement, environmental monitoring, and damage inspection after natural disasters. The authors discuss the use of UAVs as low-cost and easy-to-operate solutions for aerial reconnaissance. At present, the use of UAVs is limited by the cost of the systems and the need for skilled operators of the equipment. The researchers developed a new flight control system that will reduce the cost of autonomous UAV platforms. The emphasis of the flight controller design was to reduce the cost of implementing an unmanned aerial surveillance system. The costs were reduced in two ways: (1) by reducing the weight and volume of the flight control and payload hardware so that smaller UAVs could be used and (2) by using standard commercial off-the-shelf (COTS) components to build the hardware. This research covers the requirements of the autonomous flight control and payload system for aerial surveillance, the work done to reduce the weight of the system, and the selection of COTS hardware for the flight controller. Flight control for the aerial surveillance platform is divided into four parts: instrumentation, control, communication, and power. The UAV control system designed supports autonomous flight, including takeoff and landing, which eliminates the need for a skilled remote control pilot to operate the system. The system is designed specifically for applications with shorter flights within 3–5 mi (4.8–8.0 km) of the ground station. GPS and inertial measurement sensors localize the UAV and are inputs in the flight control algorithm. A wireless communication link between the UAV and the ground station receives flight commands and waypoints from the mission planner and transmits status monitoring information. A safety pilot can manually override the autonomous flight controller with a remote control communication link. Aerial surveillance payloads include a system to collect and wirelessly transmit video. Many also have a pan-tilt-zoom unit to position the camera to get video from different orientations. Several applications also require analog sensors or other digital input/output. Lowering the flight controller and payload weight to use smaller UAVs and by using COTS parts in the design reduced the cost of implementing an aerial surveillance system. Using smaller UAVs reduced the vehicle platform costs by a factor of three to five. Integrating the flight control hardware and the payload support hardware was the primary way the weight was reduced. Many of the components in one system were duplicated in the other. Eliminating the duplicate parts and subsystems lowered the component weight and volume (thus reducing the packaging weight). This also helps to decrease the hardware costs without sacrificing the function of the flight controller or aerial surveillance payload. All of the components are standard COTS parts with the exception of the printed circuit boards.

Forest fire detection with a small fixed wing autonomous aerial vehicle

Author(s): Martins, Alfredo;¹ Almeida, José;¹ Almeida, Carlos;¹ Figueiredo, André;¹ Santos, Filipe;¹ Bento, Domingos;¹ Silva, Hugo;¹ Silva, Eduardo¹

Year: 2007

Source: Intelligent Autonomous Vehicles, vol. 6, no. Part 1, pp. 168-173

Publisher: IFAC Secretariat

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In this work, a forest fire detection solution using small autonomous aerial vehicles is proposed. The FALCOS UAV developed for remote-monitoring purposes is described. This is a small-size UAV with onboard vision processing and autonomous flight capabilities. A set of custom-developed navigation sensors was developed for the vehicle. Fire detection is performed through the use of low-cost digital cameras and near-infrared sensors. The authors present test results for navigation and ignition detection in real scenarios.

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Statistical profile generation for traffic monitoring using real-time UAV based video data

Author(s): Puri, A.;¹ Valavanis, K. P.;¹ Kontitsis, M.¹

Year: 2007

Source: 2007 Mediterranean Conference on Control and Automation (MED 2007)

Publisher: IEEE Computer Society

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<http://www.cse.usf.edu/USL/uslababout.htm>

The authors propose the eye-in-the-sky alternative to collecting real-time temporal/spatial data by using small unmanned helicopters to monitor traffic, evaluate and assess traffic patterns, and provide accurate vehicle counts. Collected real-time visual data are converted to traffic statistical profiles and are used as continuously updated inputs to existing traffic simulation models improve calibration, accuracy (in terms of variable parameter values), and future traffic predictions. Functionality of simulation models is enhanced, and reliability is improved. The proposed approach offers significant advantages over conventional methods in which historical and outdated data is used to run poorly calibrated traffic simulation models.

A dual-flight mode MAV for situational awareness and search-and-rescue in near-earth environments

Author(s): Green, William E.;¹ Oh, Paul Y.¹

Year: 2007

Source: Association for Unmanned Vehicle Systems International—Unmanned Systems North America Conference 2007, vol. 1, pp. 334–348

Publisher: Association for Unmanned Vehicle Systems International

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Reconnaissance, surveillance, and search-and-rescue missions in near-Earth environments, such as caves, forests, and urban areas, pose many new challenges to command and control teams. Of great significance is how to acquire situational awareness when access to the scene is blocked by enemy fire, rubble, or other occlusions. Small bird-sized aerial robots are expendable and can fly over obstacles and through small openings to assist in the acquisition and distribution of intelligence; however, limited flying space and densely populated obstacle fields require a vehicle that is capable of hovering but is also maneuverable. A secondary flight mode was incorporated into a fixed-wing aircraft to preserve its maneuverability while adding the capability of hovering. With an inertial measurement sensor and onboard flight control system, the authors were able to transition from cruise to hover flight and sustain a hover autonomously. Furthermore, the hovering flight mode can be used to maneuver the aircraft through small openings, such as doorways. Fusing ultrasonic and infrared sensing, the aircraft can detect doorways and implement reactive path planning to traverse them. The ability to send UAVs into a dangerous environment to gather intelligence autonomously is the ultimate goal of this research, an invaluable resource for any command and control team.

Using tactical unmanned aerial systems to monitor and map wildfires

Author(s): Tranchitella, Michael;¹ Fujikawa, Stephen;¹ Ng, Tzer Leei;¹ Yoel, David;¹ Tatum, Don;¹ Roy, Philippe;² Mazel, Christophe;² Herwitz, Stanley;³ Hinkley, Everett⁴

Year: 2007

Source: Collection of Technical Papers—2007 AIAA InfoTech at Aerospace Conference, vol. 1, pp. 355–361

Publisher: American Institute of Aeronautics and Astronautics Inc.

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http://www.nasa.gov/centers/ames/researchpark/partners/non-profit/uav_collaborative.html

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From the first takeoff to the final night landing, it has been apparent that small tactical unmanned aerial systems have their place in the wildfire environment. The vector public unmanned aircraft system demonstrated persistent surveillance and gathered information when it was unsafe or impractical to use manned aircraft. Firefighters in the fire area commented that the system was a welcome sight overhead, knowing that critical information was being broadcast and monitored.

Multiple sensor fusion for autonomous mini and micro aerial vehicle navigation

Author(s): Winkler, S.,^{1,2} Buschmann, M.,³ Krüger, L.,³ Schulz, H.W.,³ Vörsmann, P.³

Year: 2007

Source: IEEE Region 10 Annual International Conference, Proceedings/TENCON, vol. 2007

Publisher: IEEE Computer Society

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Micro aerial vehicle (MAV) describes a category of aircraft with dimensions roughly comparable to small birds. As the smallest powered aircraft, MAVs can carry various sensors as payload to support such civil and military missions, such as traffic monitoring, weather observation, and enemy surveillance during military conflicts. To carry out more sophisticated missions and to improve the flight performance of the aircraft, a reliable navigation solution, especially of the attitude, is of significant importance. For this, an inertial measurement unit (IMU) based on micro-electromechanical systems were tightly coupled (usage of global positioning system (GPS) raw data) with GPS. The subject of this paper is the influence of the distance between the IMU and GPS antenna, the position of the GPS antenna relative to the IMU, and the number of GPS antennas used on the navigation accuracy (position, velocity, and attitude). The results presented are based on Monte Carlo simulations. They are not limited to small UAVs.

Lessons learned: Application of small UAV for urban highway traffic monitoring

Author(s): Ro, Kapseong,^{1,2,3} Oh, Jun-Seok,^{1,4} Dong, Liang^{1,5}

Year: 2007

Source: Collection of Technical Papers—45th AIAA Aerospace Sciences Meeting, vol. 10, pp. 7160-7178

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Traffic and emergency monitoring systems are essential constituents of intelligent transportation system (ITS) technologies, but the lack of traffic monitoring has become a primary weakness in providing prompt emergency services. Demonstrated in numerous military applications, UAVs have great potentials as a part of ITS infrastructure for providing quick and real-time aerial video images of large surface areas to the ground. Despite the obvious advantages of UAVs for traffic monitoring and many other civil applications, it is rare to encounter success stories of UAVs in civil applications, including transportation. The objective of this paper is to report the outcomes of research supported by the State agency to investigate the feasibility of integrating UAVs into urban highway traffic monitoring as a part of ITS infrastructure. These include current technical and regulatory issues and possible suggestions for a future UAV system in civil applications.

A fixed-wing aircraft for hovering in caves, tunnels, and buildings

Author(s): Green, William E.;¹ Oh, Paul Y.¹

Year: 2006

Source: Proceedings of the American Control Conference, vol. 2006, pp. 1092-1097

Publisher: IEEE Computer Society

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Micro air vehicles (MAVs) are small bird-sized aircraft with applications in reconnaissance, search-and-rescue, airborne agent and pathogen detection, and target acquisition. Fixed-wing MAVs cannot hover and thus are not able to fly in tight, enclosed spaces. Rotary-wing platforms can hover but are limited in endurance. The authors of this paper present a fixed-wing MAV with a secondary flight mode (i.e., hovering), allowing it to fly in caves, tunnels, and buildings. The sensing and control system used to achieve autonomous hovering is also described. This is, to the best of the authors' knowledge, the first documented success of autonomously hovering in a fixed-wing MAV in the open literature.

Autonomous hovering of a fixed-wing micro air vehicle

Author(s): Green, William E.;¹ Oh, Paul Y.¹

Year: 2006

Source: Proceedings—IEEE International Conference on Robotics and Automation, vol. 2006, pp. 2164-2169

Publisher: IEEE Computer Society

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In recent years, there has been a need to acquire intelligence in hostile or dangerous environments, such as caves, forests, or urban areas. Rather than risking human life, back-packable, bird-sized aircraft, equipped with a wireless camera, can be rapidly deployed to gather reconnaissance in such environments; however, the aircraft first must be designed to fly in tight, cluttered terrain. The authors discuss an additional flight modality for a fixed-wing aircraft, enabling it to supplement existing endurance superiority with hovering capabilities. An inertial measurement sensor and an onboard processing and control unit, used to achieve autonomous hovering, are also described. This is, to the best of the authors' knowledge, the first documented success of a hovering a fixed-wing micro air vehicle autonomously.

Traffic flow data extracted from imagery collected using a micro unmanned aerial vehicle

Author(s): Coifman, B.;^{1,2} McCord, M.;¹ Mishalani, R. G.;¹ Iswalt, M.;¹ Ji, Y.¹

Year: 2006

Source: Applications of Advanced Technology in Transportation—Proceedings of the Ninth International Conference on Applications of Advanced Technology in Transportation, pp. 298–303

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Roadway networks span large distances and can be difficult to monitor. Most efforts to collect roadway usage data either require a large fixed infrastructure or are labor intensive. Advances in electronics and communication have recently enabled an alternative. UAVs capable of carrying sensors and communications hardware to relay data to the ground are now commercially available. In this paper, the authors investigate the feasibility of using a UAV to monitor roadway traffic and develop several applications. UAVs can cover large areas and travel at high speeds and are not restricted to traveling on the road network. This paper demonstrates several applications by using data from a UAV flying in an urban environment—determining level of service, estimating average annual daily travel, documenting intersection operations, and measuring origin–destination flows. The descriptions of these empirical tasks are intended to provide the main concepts and methods applied to derive useful information for both off-line planning and real-time management and to illustrate the challenges and opportunities such applications pose.

Remote Sensing

Development of UAV-based remote sensing capabilities for highway applications

Author(s): UTC Spotlight, University Transportation Center Program

Publisher: Research and Innovative Technology Administration (RITA)

Year: 2012

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Researchers from West Virginia University have successfully demonstrated that a low-cost, remotely controlled aircraft can provide a stable aerial platform with the potential to aid transportation professionals in a variety of research and applied uses. The small UAV acquires high-resolution images that could be used in work zone management, traffic congestion, safety, and environmental impact studies. Compared with fixed-position ground sensors, airborne sensors offer mobility and measurements from multiple perspectives. In addition, UAVs can be used to perform missions within hazardous environments without endangering the operators.

***AggieAir—A low-cost autonomous multispectral remote sensing platform:
New developments and applications***

Author(s): Jensen, Austin M.;¹ ² Chen, YangQuan;² McKee, Mac;¹ Hardy, Thomas;¹ Barfuss, Steven L.¹

Year: 2009

Source: International Geoscience and Remote Sensing Symposium, vol. 4, pp. IV995–IV998

Publisher: Institute of Electrical and Electronics Engineers Inc.

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Data acquired by aircraft, satellites, and other sources of remote sensing have become very important for many applications. Although current platforms for remote sensing have proved to be robust, they can also be expensive, have low spatial and temporal resolution, and have a long turnover time. At Utah State University, there is an ongoing project to develop a new, small, low-cost, high-resolution, multispectral remote sensing platform that is completely autonomous, easy to use, and has a fast turnover time. Many new developments have been added to AggieAir that have improved flight performance and flexibility, increased flight time, and increased payload capacity. Furthermore, these developments have made it possible to carry an imaging system with more quality and resolution. With these new developments, AggieAir has been incorporated into many projects, from areas in agriculture, riparian habitat mapping, highway and road surveying, and fish tracking. Development on AggieAir continues with future plans with a thermal inferred camera, an in-house inertial measurement unit, and better navigation to handle higher winds.

Evaluation of remote sensing aerial systems in existing transportation practices

Author(s): Gu, Yu¹

Year: 2009

Source: Final Report 07/01/2008-06/30/2009

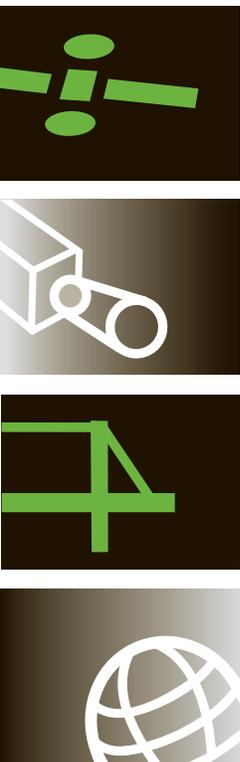
Publisher: Department of Mechanical and Aerospace Engineering,
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The application of small remotely-controlled (R/C) aircraft for aerial photography presents many unique advantages over manned aircraft due to their lower acquisition cost, lower maintenance requirements, and superior flexibility. The extraction of reliable information from these images could benefit Department of Transportation engineers in a variety of research topics including, but not limited to, work zone management, traffic congestion, safety, and the environment. During this effort, one of the West Virginia University R/C aircraft, named “Foamy,” was instrumented for a proof-of-concept demonstration of aerial data acquisition. Specifically, the aircraft was outfitted with a Global Positioning System (GPS) receiver, a flight data recorder, downlink telemetry hardware, a digital still camera, and a shutter-triggering device. During the flight, a ground pilot used one of the R/C channels to remotely trigger the camera. Several hundred high-resolution geo-tagged aerial photographs were collected during 10 flight experiments at two different flight fields. A Matlab-based geo-reference software was developed for measuring distances from an aerial image and estimating the geo-location of each ground asset of interest. A comprehensive study of potential sources of error (SOE) was also performed with the goal of identifying and addressing various factors that might affect the position estimation accuracy. The conclusion of the SOE study was that a significant amount of position estimation error was introduced by either the mismatching of different measurements or by the quality of the measurements themselves. The first issue is partially addressed through the design of a customized Time-Synchronization Board (TSB) based on a MOD 5213 embedded microprocessor. The TSB actively controls the timing of the image acquisition process, ensuring an accurate matching of the GPS measurement and the image acquisition time. The second issue is solved through the development of a novel GPS/INS (inertial navigation system) based on a nine-state Extended Kalman filter. The developed sensor fusion algorithm provides a good estimation of aircraft attitude angle without the need for using expensive sensors. Through the help of INS integration, it also provides a very smooth position estimation that eliminates the large jumps typically seen in the raw GPS measurements.



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