

Demo Abstract: A Drone-based System for Intelligent and Autonomous Homes

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ABSTRACT

Homes are becoming more intelligent due to the growth of smart sensors and devices found in typical homes. However, most of these sensors and devices function independently from one another, limiting the amount of utility and services a truly "smart" home can provide. In this demonstration, we introduce two key ideas towards more intelligent homes. First, we explore the usage of mobile drones in the home environment. Second, we propose DIA, a system that seamlessly connects to the home environment and automatically discovers and jointly utilizes smart sensors and actuators around the home to provide services that are otherwise not possible. We demonstrate three services that DIA enables.

CCS CONCEPTS

- Computer systems organization → Sensor networks; Sensors and actuators.

KEYWORDS

smart homes, drones, edge computing, artificial intelligence

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1 INTRODUCTION

The growth of home assistants and smart devices have made homes and the built environment more and more intelligent, enabling numerous applications such as [2–4]. Currently, around 70% of homes in the United States have at least one smart device [1].

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However, while there are now more smart devices found in homes, most of these devices function independently, limiting their true potential. In this work, we propose two key ideas that will help realize our vision of autonomous and intelligent homes.

First, we explore the idea of utilizing drones within the home environment. Drones have been explored in many outdoor contexts, but relatively few works explore their utility as a mobile sensing and actuating platform in homes. Since the cost of drones has been rapidly decreasing in recent years, we envision that drones will soon become prevalent in indoor and home environments.

Second, we introduce DIA, a Drone-based system for intelligent and autonomous homes that connects to the home network and automatically discovers smart sensors and actuators located within the home. After discovering resources present, DIA then jointly and dynamically leverages discovered devices to provide higher-level services and applications otherwise not possible.

2 SYSTEM ARCHITECTURE

Figure 1a shows the architecture and pipeline of DIA. Figure 1b shows an example of how DIA would tackle the problem of privacy-aware fall detection, where the goal is to alert family and healthcare personnel whenever a person falls and is unable to stand back up. When the system first connects to the home network, it launches a **discovery** process that finds available sensors and actuators within the home environment. In the example scenario provided, we assume the home has vibration sensors, proximity sensors, and a home assistant device that can record audio. We also assume the home comes equipped with a drone with a camera module attached.

Next, the system **categorizes** sensors and devices into services they benefit. In our example scenario, the system determines it can utilize vibration sensors, acoustic sensors, and the drone to detect falls while it can utilize the proximity sensor, acoustic sensors, and the drone for intruder detection.

Then, when the system receives a command to perform a task, the system **executes** the command based on the discovered and categorized sensors. In our fall detection example, a user gives the command "alert me if my mother falls" by speaking into his home assistant device. The system, with the goal of executing this task in the most privacy-sensitive way, determines that of the three sensors allocated to this task (vibration, microphone, drone), the vibration sensor is the most privacy-preserving modality and decides

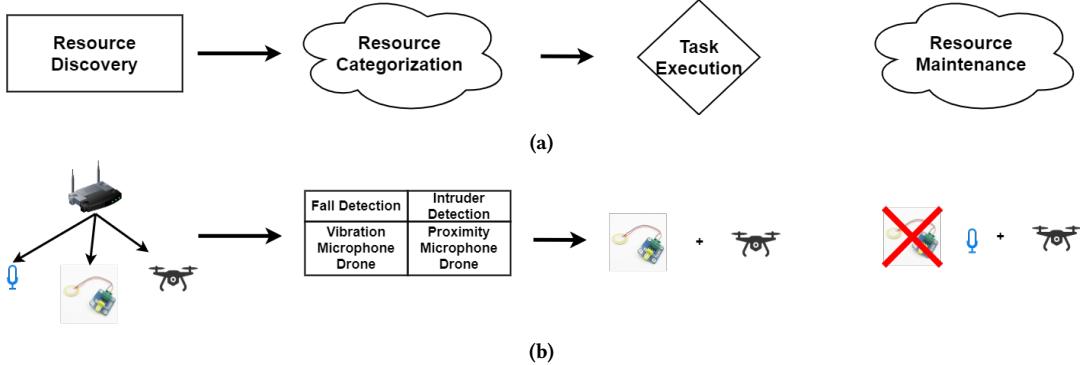


Figure 1: a). DIA system architecture. DIA allows for high levels of home autonomy and intelligence through a four-block approach: *discovery* of sensors and smart devices, *categorization* of devices into different services, dynamic task *execution* based on devices allocated to each service, and *maintenance* which periodically updates the state of available devices and dynamically adjusts how each task is executed. **b).** An example of how DIA conducts privacy-aware fall detection.

to utilize it to monitor for falls. However, detecting falls through vibrations is the least accurate because vibrations will occur if anything moves in the vicinity of the sensor. As such, whenever the system detects a potential fall using vibration sensors, it will confirm the fall by flying the drone over to analyze video footage of the scene. In this way, our system allows the home to utilize the high detection accuracy afforded from images while preserving privacy by leveraging less invasive vibration sensors.

Finally, the system continues to **maintain** the collection of available sensors, actuators, and services. If any changes occur in the collection of smart devices found within the home environment, our system will detect and dynamically change the way it executes tasks. For example, in fall detection, if the vibration sensors become unavailable or defective our system will leverage the next sensor, the microphone, to detect a person's cry for help after falling.

3 ENABLED APPLICATIONS

We envision that by incorporating drones and DIA into future homes, we can enable the following classes of applications:

- **Home surveillance:** The addition of mobile drones in smart homes allows almost any physical entity to be monitored in the home environment.
- **Home security:** Using our system, smart homes can leverage drones in conjunction with other static sensors to provide greater coverage in intrusion monitoring.
- **Health monitoring:** Smart homes can intelligently leverage drones and other sensors to continuously monitor the health and safety of its occupants. Drones may also assist in transporting medicine and medical devices.
- **Entertainment:** The addition of drones can enable more avenues of entertainment and greater convenience.

4 DEMONSTRATION DESCRIPTION

In this demonstration, we will show three applications in home environments that can benefit from the addition of drones and DIA:

- **Fall detection:** By leveraging drones along with low-fidelity sensors, a smart home can continuously monitor the environment for falls for long periods of time with high fidelity.
- **Automatic selfie:** A smart home can intelligently leverage existing home cameras and drones to take pictures of users on command without having users lift a finger.
- **Digital fence:** Homeowners may want certain people to avoid certain areas of the home for various reasons. For instance, parents may want to their children to avoid the tool shed due to the abundance of dangerous tools.

In each application, we will deploy a series of low-fidelity sensors that will be commonplace in future smart homes, such as vibration and proximity sensors, and demonstrate how DIA is able to discover and utilize these sensors in conjunction with a small and low-cost drone to provide more complex home services that are otherwise not possible, even as the number and types of active sensors change.

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