An Unmanned Aerial Vehicle System for Detecting Roof's Leakage

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Commercial buildings and most of high-rise buildings for living often have flat roofs, which are notoriously prone to leakage. In fact, up to 40% of flat roofs develop serious problems within one year of installation.

With the increased popularity of green roofs, walkways, plaza decks and solar panels, the ability to quickly find and repair faulty roofing membranes has never been higher.

Leaky roofs cost billions of dollars annually, with damage ranging from minor water stains and electrical outages to complete structural failure of the roof. Using traditional methods, this testing can be time-consuming, messy, and actually damage the roof [1].

For many years, the most common method of testing for roof leaks has been flood testing. But the cost for replacing a roof membrane is about one-tenth the price of replacing the entire roof, so owners see it as a cost-effective precaution. This method obviously has drawbacks and it is noted that flood testing is not a reliable quality assurance method and that the risks associated with flood testing far outweigh any potential benefits

In recent decades, though, new technology has been developed that avoid these problems, saving time, money and equipment. These technologies are non-invasive, non-destructive, and far more reliable than flood testing and direct observation.

The most popular are infrared thermography, nuclear moisture testing, electrical impedance testing, and electric field vector mapping.

The first three techniques actually test for water in the roof assembly. The last two will actually pinpoint the leak, even if it's too small to be seen easily.

Infrared thermography is based on the principle that water and wet insulation changes temperature more slowly than dry roofing components. When a leak develops, water enters, and depending on the type of insulation, is either absorbed or runs to the cracks between the nonabsorbent insulation. As night begins to fall and temperatures drop, dry insulation in the roof will cool quickly while the wet insulation holds its temperature. Using an infrared camera, the thermographer sees which areas are warmer than the surrounding components which usually indicate wet insulation. The best results typically occur on cool, clear, calm nights following clear, sunny days. Of the methods considered non-destructive, infrared thermography has advantages over the others, making it the more frequently used method. Infrared scanning allows technicians to sample the entire roof, rather than possibly only 2 percent of the roof area when using a 10-foot-square grid pattern required for individual tests when using other methods. Infrared thermography does have drawbacks. For instance, some insulation that doesn't absorb water and don't return good results. Also, an area might appear warm because of mechanical equipment, heaters under the roof deck, or a thinner gravel surfacing [1].

Nuclear moisture testing works like a type of atomic radar. It's sometimes called nuclear hydrogen detection, since it actually detects hydrogen levels, not water. The tester uses a hand-held device that emits a stream of high velocity neutrons. When the neutron strikes a hydrogen atom, it bounces back to the device at a slower speed. Since water has a high percentage of hydrogen atoms, the machine can interpret the results as a percentage of moisture. Interestingly, asphalt also contains a large percentage of hydrogen atoms, so a baseline reading needs to be taken in a known dry area of the roof, from which the meter can be calibrated.

Electrical impedance testing produces results very similar to the test above. Because water conducts electricity, wet insulation provides less resistance to electrical current than dry insulation does. As in nuclear moisture testing, a grid is set up, and readings taken at each point. High readings indicate the probability of moisture intrusion, which is then verified using core samples. The technology is very similar to the instruments used to measure moisture content in the lumber and paper industries.

Electronic leak detection comes in two different varieties, high voltage and low. Both have advantages over nuclear, infrared, and impedance testing in that they pinpoint the actual breach in the membrane, not simply the presence of water. The key to these methods is that water conducts electricity very well at least 10 times as well as most roofing membranes. The high voltage method uses relatively high voltage but low amperage. It requires the structural roof deck to be conductive (either metal or concrete) and the membrane to be an insulator. The membrane must also be completely exposed. One electrical lead is connected to the roof decking, and the other is attached to device resembling a push broom with copper bristles. As the operator "sweeps' the surface of the membrane, any moisture or breach in the membrane will complete the circuit between the measuring device and the roof deck. Electric field vector mapping (EFVM) uses lower voltages than the system just described, and has several advantages over other testing methods. For instance, EFVM works on exposed, ballasted or concealed membranes, and the roof doesn't have to be perfectly dry. It can be employed on vertical, sloped or flat surfaces, overburden can stay in place during testing, and it locates leaks and breaches with pinpoint accuracy [3].

EFVM involves wetting the top of the membrane to create an upper electrical "plate". Often, the overburden will contain enough moisture that wetting the roof is not necessary. Like the high-voltage system described above, the structural deck acts as the lower electrical plate, and the roof membrane located in between acts as the insulator. If there is a hole or an opening in the membrane (for water to penetrate), an electrical contact will be established between the two plates through the defect. Using specialized probes, the technician can determine the direction of the current, thereby determining the location of the defect in the surface membrane. Once a reading is determined, the technician will take additional readings in order to verify the exact location of water entry, allowing remediation processes to be accurately targeted [1].

But all described methods have one very significant drawback: all of them need technician or operator on the roof, that is very dangerous and not safely.

Now days a rapid growth globally in the acquisition and development of Unmanned Aerial Vehicles (UAVs) is observed. UAVs are increasingly performing civilian tasks as the technology becomes more common – 57 countries and 270 companies were producing UAVs in 2013 [3].

Unmanned Aerial Vehicles (UAVs), commonly referred to as drones, are remotely piloted aircraft or systems. Other names for these types of aircraft are remotely piloted vehicle (RPV), remotely piloted aircraft (RPA), and remotely operated aircraft (ROA).They range from simple hand-operated short-range systems to long endurance, high altitude systems that require an airstrip.

One of the founding fathers of the idea of remotely controlled vehicles was the genial civil inventor - Nicola Tesla. In fact, Tesla was the first to patent a remote-control for unmanned vehicles (which he described as 'teleautomation'), becoming one of the foundational principles for today's UAV's [4].

Designed initially for reconnaissance purposes, their para-military and commercial development was often out of sight of the public. As the technology becomes more advanced and costs fall, civilian day-today uses of UAVs are developing rapidly [5]. Drones of all types have already been used in a wide range of practical ways, including: archaeological surveying, science, in general; environmental/meteorology; e.g., climate study, storm monitoring, mapping glaciers, general data collection; military - surveillance, air strikes; security - surveillance, crowd monitoring and control; law enforcement - surveillance, traffic monitoring, search and rescue operations.

UAVs come in a wide variety, but can be divided into classes based on size, range, and capacity for autonomous flight. While most are controlled remotely by a human pilot on the ground, some can fly along pre-set coordinates or patterns, or land if they lose contact with the pilot.

Medium to large systems: These vehicles range from dozens of kilograms to the size of a manned plane. They can fly at high or medium altitudes for hours or days at a time, hundreds or thousands of miles from their operators. Costing from hundreds of thousands to millions of dollars, they require sophisticated base stations and extensive pilot training.

Small systems (mini and micro-UAVs): These systems are small enough to be carried by one or two people, with some easily fitting in a backpack or weighing less than a kilogram. They can include both fix-wing aircraft, better at distance flying, and rotor aircraft that can hover. These systems are generally limited in range to anything from line of sight to a few kilometers, and to flight times under an hour. Operating these systems is much simpler, with little training required. Professional-grade systems can carry sophisticated cameras and GPS equipment and increasingly have the capacity for autonomous flight, object avoidance and other safety features. Costs can range from $5,000 to several hundred thousand dollars, including analytical software and support [3].

The most common use of in humanitarian response today is data-collection and observation.

Here is presented one more UAVs civil using for detecting roof's leakage. Designed device must include some detectors that can determine leakages and other defects of the roofs, by non-destructive control method. The main idea is to use infrared thermography and observation by camera.

This article sets the direction for further researches. The project is at an early stage and a lot of things will be modified. There are great prospects of development in this direction in instrument making industry. In consideration of the work is analyzed the relevance of the chosen theme.

Such invention will help to analyze the condition of the roof of any height and will help to keep the human-operator in the safety.

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Unmanned Aerial Vehicles on the World Market

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Unmanned Aircraft Systems (UAS) is an emerging technology with a tremendous potential to revolutionize warfare and to enable new civilian applications. It is integral part of future urban civil and military applications. It technologically matures enough to be integrated into civil society. In recent years, the term UAV (Unmanned Aerial Vehicle) has been replaced with the term UA which stands for Unmanned Aircraft. To emphasize that a UA is a part of a complete system including ground operator stations, launching mechanisms and so forth, the term Unmanned Aircraft System (UAS) has been introduced . That system whose components includes the necessary equipment, network, and personnel to control an unmanned aircraft also called UAS [1].

An unmanned aircraft system is a system comprised of three main features: the aircraft, the Ground Control Station (GCS or C3) and the operator.