



Nordic district heating networks monitored from the sky with thermal imaging

District heating is a system for distributing heat generated in a centralized location for residential and commercial heating. Hot water or steam is distributed to households and companies through an underground network of pipes. District heating can potentially help to reduce a city's carbon footprint by increasing the efficiency of heating systems throughout the entire city. According to some researchers district heating is the cheapest method for a city to cut on carbon emissions. But maintaining a large district heating network can be a difficult task. To help large Scandinavian cities to effectively monitor and maintain their district heating networks, the Linköping, Sweden, based company Termisk Systemteknik has developed a district heating scanning system from the sky, based on thermal imaging cameras from FLIR Systems.

For the district heating inspections the thermography experts at Termisk Systemteknik have mounted a FLIR SC7600 on the bottom of a small plane. By flying over the city and recording the thermal images, a thermal map is produced of the entire city on which district heating leaks can be detected and localized. An automatic detection system is unleashed on the thermal data to automatically point out leaks and other issues to the district heat maintenance teams. "To be able to arrive at this result we needed to perform a lot of research ourselves", explains Stefan Sjökvist, director of Termisk Systemteknik. "To my knowledge no such system existed before we designed it."

The FLIR SC7600 thermal imaging camera that was used for the district heating monitoring system contains a cooled Indium Antimonide (InSb) infrared detector that produces thermal images with a resolution of 640 x 512 pixels at a thermal sensitivity of 20mK (0.02 °C). "It is especially useful for this application because of its high frame rate and short integration time. It can capture the full resolution at a frame rate of 100 Hz. Such high speed acquisition and short integration time is indispensable when you are flying over a city at moderate speed and want sharp and clear images."

Old pipes require a modern detection tool

Localizing leaks in district heating is of utmost importance to the companies



The FLIR SC7600 thermal imaging camera is mounted in a plane, looking straight down through an opening in the plane's hull.



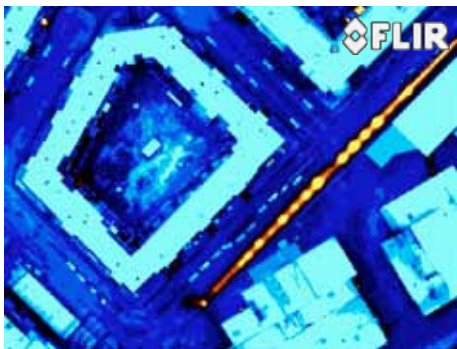
A gyro-stabilized platform compensates for the plane's movements, enabling the FLIR SC7600 thermal imaging camera to record steady thermal images.

administering the district heating systems, according to Sjökvist. "Here in Scandinavia district heating systems have been installed in many of the larger cities. But a significant portion of the district heating infrastructure is quite old. Some parts were installed in the fifties and sixties. Old pipes tend to degenerate over time due



to corrosion and will eventually start to leak. The exact numbers may vary but each year the Swedish companies alone lose several million cubic meters of water. This constitutes not only a large financial loss, but also a loss to the environment as well."

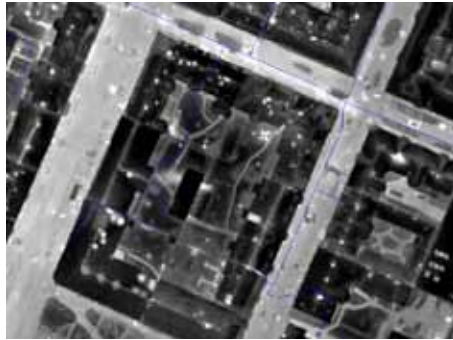
Finding these leaks with conventional means is quite difficult, however. "The district heating companies usually measure the amount of water that leaves the centralized heating facility and the amount of water that arrives at each building or household. Some substations also make these measurements. Using this information they can see how much water is lost to leaks for large areas. But this gives no detailed information on where these leaks are located. Finding the leaks manually requires the pavement to be opened up, which is a very costly affair in itself, especially if no leak is found in that location."



This un-analyzed thermal image already clearly shows leaks in a district heating pipe.

Thermal map of the entire city

That is why Termisk Systemteknik has developed their district heating service. "We fly over the city, mapping the entire area. A Global Positioning System, several gyroscopes, a digital compass and several other pieces of equipment that we have installed on the plane allow us to very accurately geo-reference each captured thermal image. These are then stitched together into one large map of the entire city."



The thermal images are analyzed and an extra layer of information is added. District pipelines are marked with blue lines. Green outlines mark smaller leaks and red outlines mark serious leaks that require immediate attention.



To make sure each pixel is accurately linked to the right physical location, specially developed software compares the thermal images with official maps and satellite images, where necessary automatically stretching or twisting the thermal image slightly to compensate for tiny differences in the viewing angle due to non-linear motions of the plane. The result is a thermal map made up out of several thousands of single images of the entire city. "This map can be accessed in a way that is very similar to Google Maps. The maintenance personnel of the district heating company can easily zoom in and out, add layers of information, tweaking thermal images to review particular locations."

The resulting map contains a layer of information on the location of district heating pipework and of the location of detected leaks. "Some locations require immediate attention. Large volume leaks not only lose the company money, but can be dangerous too, with all the boiling hot water spilling out. Other locations indicate leaks that are developing. Old and deteriorating insulation causes warmth to leak out, cooling down the water, effectively losing energy. These might not be urgent, detecting such locations allows the district heating companies to plan maintenance on those pipes before they deteriorate further, which would no doubt cause leaks later on."

Automated detection and classification of leakages

To be able for the analysis software to automatically point out leaks to the user, a lot of information needed to be filtered out, according to Sjökvist. "Vehicles, pedestrians, animals, insulation faults in roofs, all of these very common phenomenon cause thermal radiation that can potentially pop up as an unwanted alarm. That is why we used our knowledge about thermal signature detection to identify these parts of a thermal image in order for the automatic leak detection software to ignore those parts of the thermal image."

Further improvements

One area where Sjökvist sees room for improvement is the amount of human involvement needed. "We want to further automate the map production process. This process is now semi-automatic, which means that human involvement is still necessary, in order to oversee the activities of the computer and to double check for inaccuracies in the stitching for example. We want to perfect that part of the process in order to limit the amount of man hours needed and speed up the delivery of our reports and of the post analyzing software to the customers."



After seeing this leak in the report, the district heating company went there to investigate. It turned out to be a very large leak. Needless to say the company was very glad that this major leak was detected.

For more information about thermal imaging cameras or about this application, please contact:

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