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SOLUTIONS FOR UPPER MID-RISE AND HIGH-RISE MASS TIMBER CONSTRUCTION

INFRARED IMAGING FOR FIRE RISKS

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FPInnovations

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SOLUTIONS FOR UPPER MID-RISE AND HIGH-RISE MASS TIMBER CONSTRUCTION:

INFRARED IMAGING FOR FIRE RISKS

PROJECT NO. 301013070

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1. INTRODUCTION

Fire safety during construction of multi-storey wood buildings is a major concern for developers, insurers, and the fire service. This is particularly true for mid-rise buildings (up to six storeys), taller buildings approved through Alternative Solutions, and potentially Encapsulated Mass Timber Construction (EMTC) buildings proposed up to 12 storeys for the 2020 National Building Code of Canada [1]. These taller and larger wood buildings have unique fire risks during construction; it is important to understand these risks to be able to mitigate them. Fire safety during construction has historically been a difficult issue to address, since building code regulations apply to the completed structure and do not necessarily need to be met during the construction phase.

Although prefabrication of timber elements is expediting construction timelines and reducing fire hazards on site, there is still a critical timeframe during construction when wood elements are exposed. Advanced fire detection methods are needed on these sites, in particular before other active fire protection systems are installed. The earlier a fire is detected, the greater the opportunity the fire service has to extinguish it before it is able to spread.

2. BACKGROUND

FPInnovations has been researching fire safety risks during construction over the last several years. In 2016, a report was published which reviewed the state of fire safety practices during construction in Canada, listed available resources, and surveyed various technologies that had the potential to improve fire safety on construction sites; thermography/infrared imaging, Building Information Modeling (BIM), and unmanned aerial vehicles (UAVs or drones) were assessed to be promising tools to address fire risks [2]. This work was followed up with the initiation of the development of a small proof-of-concept infrared camera system that was designed to identify fires early in the growth phase using an image analysis algorithm, named IRFD; the camera is shown in Figure 1 [3]. The system was designed to be suitable for the wood building construction environment which included being small, low-cost, and able to detect small fires quickly. It used a FLIR Lepton camera and a small computer board. The ultimate intention was to have multiple wireless cameras throughout a site and to provide online real-time access.

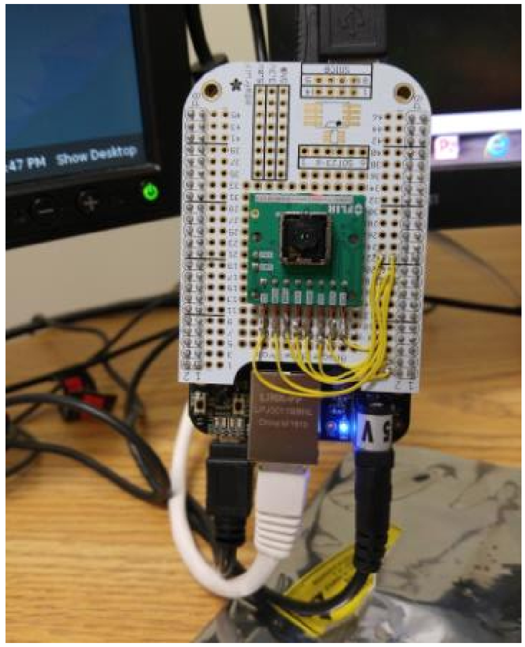

Figure 1. IRFD

The project was continued in 2018 which brought updates to the system [4]. The updated system was referred to as IRFD-2. Hardware was upgraded, the image analysis algorithm was refined, and a web-based user interface was developed for future integration into the system. Limited testing of the system was conducted using different heat sources at different distances. An example of the user screen during detection of a fire is shown in Figure 2. The system was still in the proof-of-concept stage and needed further development before commercialization. This included integration of wireless capabilities, investigation of better suited hardware components, and design of an exterior system housing.

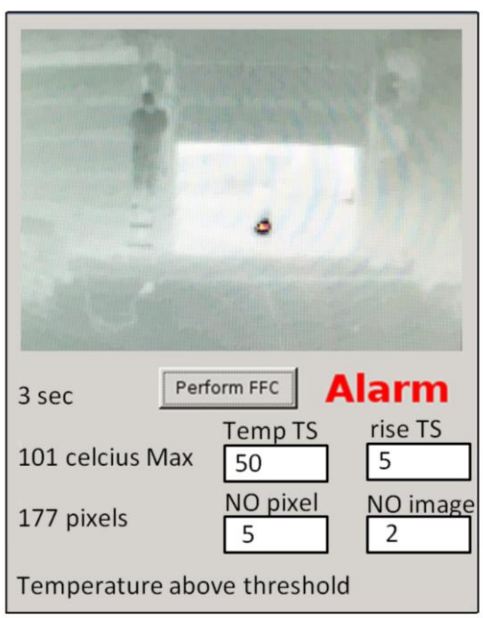

Figure 2. Example output of IRFD-2 during fire detection testing

3. OBJECTIVE

The overall objective of this project is to develop an innovative tool to address fire risk on wood construction sites. The intent was to build on previous work and continue the development of an infrared camera system for the detection of fires on wood construction sites. The goal was to advance the camera towards commercialization.

4. TECHNICAL TEAM

Lindsay Ranger	Scientist, Building Systems
Patrick Levesque	Senior Scientist, Building Systems

5. PROCEDURE

In 2017/2018 the IRFD camera was updated to improve its detection capability, improve hardware components, and integrate additional features into the system. The camera was tested and shown to be effective at detecting different hot bodies at a variety of distances. It was suggested that more standardized testing take place to evaluate the overall performance of the camera. At the end of that project it was determined that several aspects required further research and development to bring the camera to commercialization.

This included:

1. Identifying appropriate hardware components for use in the field:
    a. Select better suited computer board;
    b. Investigate and incorporate wireless power source and communication;
2. Integration of remote data storage;
3. Development of a user interface to access storage;
4. Design custom external housing to protect cameras on site Introduction of multiple cameras.

This represented a significant amount of work and financial commitment before the system would be ready for commercialization.

The development of computer systems is not the expertise of FPInnovations, therefore a software development and electronic product design company was approached to consult on the development of the system towards commercialization. A preliminary diagram block and a list of suggested components and necessary firmware were generated to provide to the client. This information can be found in Appendix I. The consultant provided a proposal to develop the camera unit which exceeded the overall allocated budget for the project, this did not include development of server software to monitor alarms and provide users with access to camera data.

The list of tasks they identified as necessary included, but was not limited to, the following:

- Integrate a COTS (commercial off-the-shelf) infrared imaging camera and related fire-detection algorithms (mostly reusing the results of the previous phase);
- Develop a small, robust and affordable platform (reusing COTS components where possible) for deployment in harsh conditions (outdoors, dusty, with batteries and/or solar power to complement regular power supply that is intermittent on construction sites);
- Integration of batteries and development of power management features on the camera device (hardware, firmware, software);
- Evaluation, selection, testing and integration of wireless communications subsystem to allow communications of camera devices with fixed servers, including firmware and diagnostics related to communications subsystem;
- Integrate communication module to send alarms and some pictures to a cloud-based server (low-cost networking possibilities need to be further refined for deployment on construction sites);
- Add ability to simplify monitoring and operations of several of those cameras on the same site (health monitoring, simplify planning of installation points and camera-pointing direction to cover the important areas, etc.);
- Various hardware, firmware and software improvements and documentation;
- Perform laboratory and real-life testing to ascertain performance and accuracy, with single-camera and multi-camera deployments.

Development Partner

After this, it was decided that to be successful in development of this technology, FPInnovations needed to identify a partner to help further advance and commercialize the product. Ideally the partner would work with FPInnovations on the development and bring the product to market. The scientists worked with the FPInnovations Business Development and researched potential partners.

The National Optics Institute (INO) was investigated as a partner. They were approached during initial development of the IRFD and expressed interest in the project. They are a leader in the development of industrial optical solutions. After consideration, a mutual partnership was not pursued.

Pillar Technologies was also considered. During the course of the project, they launched a construction site risk management product that operated on a similar premise as the IRFD. Their technology uses construction site job sensors that are connected to a software analytics platform which allows users to access sensor data on a variety of devices (i.e. computer or mobile applications). The sensor units, shown in Figure 3, are deployed around a building and provide builders with real-time access to the sensor data. Alerts are sent if any trouble criteria are detected. The Pillar Technologies systems:

- Allow users to view and manage sensor data;
  - Sensors include: temperature, humidity, pressure, VOC, dust, smoke;
- Actively monitor site conditions, provides access to real-time data;
- Document site conditions and sends alerts when problems are detected;
- Detect poor site conditions so that they can be addressed before damage occurs;

- Uses a wireless connection (cellular);
- Are battery powered to run for up to 10 months.

Figure 3. Pillar Technologies sensor unit [5]

FPInnovations contacted Pillar Technologies to gauge their interest in partnering on this project. Ultimately, it was determined that Pillar Technologies, being a start-up company, did not have the resources to continue development of this system, despite having existing software infrastructure that could potentially be used with the IRFD system.

Eventually the decision was made to halt the project until a suitable partner could be found and a mutual agreement could be reached.

6. CONCLUSION

FPInnovations has been working over several years to mitigate fire risks for wood construction sites. The development of an infrared camera system was identified as a potentially useful tool to help quickly identify fires on wood construction sites. Over two years, a proof-of-concept camera system was investigated and developed. Eventually, it was determined that a partner was needed to help advance the system towards commercialization. FPInnovations investigated different potential partners, but no formal partnership agreements were made. The project was halted until an appropriate partner can be identified a mutual development agreement can be reached.

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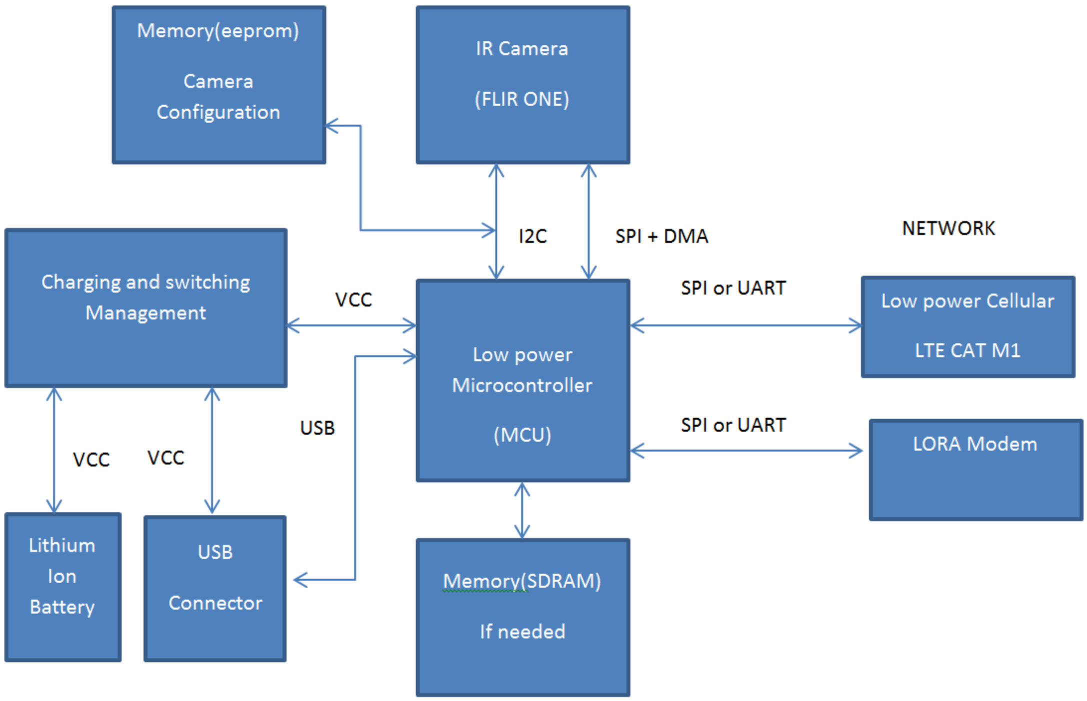
APPENDIX I - DIAGRAM BLOCK, COMPONENTS AND FIRMWARE REQUIREMENTS

Preliminary Diagram Block



Possible Components

1) **MCU (ex: PIC32 XLP):** low power mcu, 1xSPI, 1x I2C, 1xUART, 1xUSB, DMA, RAM needed? Operation frequency needed?
2) **MCU:** the interface DMA can be used for unloading the CPU load (SPI).
3) **SDRAM**: Maybe we will need an external SDRAM for storing pictures in memory and the tasks.
4) **LTE CAT M1 (ex: SARA-R4 ublox):** low power cellular @ 375kbs. This device is supported by Bell and we don't need a PTCRB with Bell. Don't need an infrastructure. Need a data plan at around 5$/month.
5) **LORA:** Stars Network. Need to install an infrastructure. Don't need a data plan. Link budget at around 150db @ 9600bauds. Can transmit at 250 kbs. The router can be connected to the internet.
6) **Eeprom:** read and store the configuration. Read and store the pictures.
7) **IR Camera:** Flir Lepton 3 (160 x 120).
8) **Charging and switching power management:** Use the power from the battery when the usb is not connected. Use the power from the usb when the usb is connected. Read the voltage level from the battery. Charge the battery if the usb is connected.
9) **Battery:** Lithium ion battery. Capacity mAh? Discharging time? Charging protection if below zero degree.
10) **USB:** Will serve for configuring the camera, display the pictures from the camera live.

Firmware

1) Must use a real-time operation system (ex: freeRTOS)
2) A framework is available for the MCU (ex.: the API stack for the USB and all drivers for the peripherals).

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