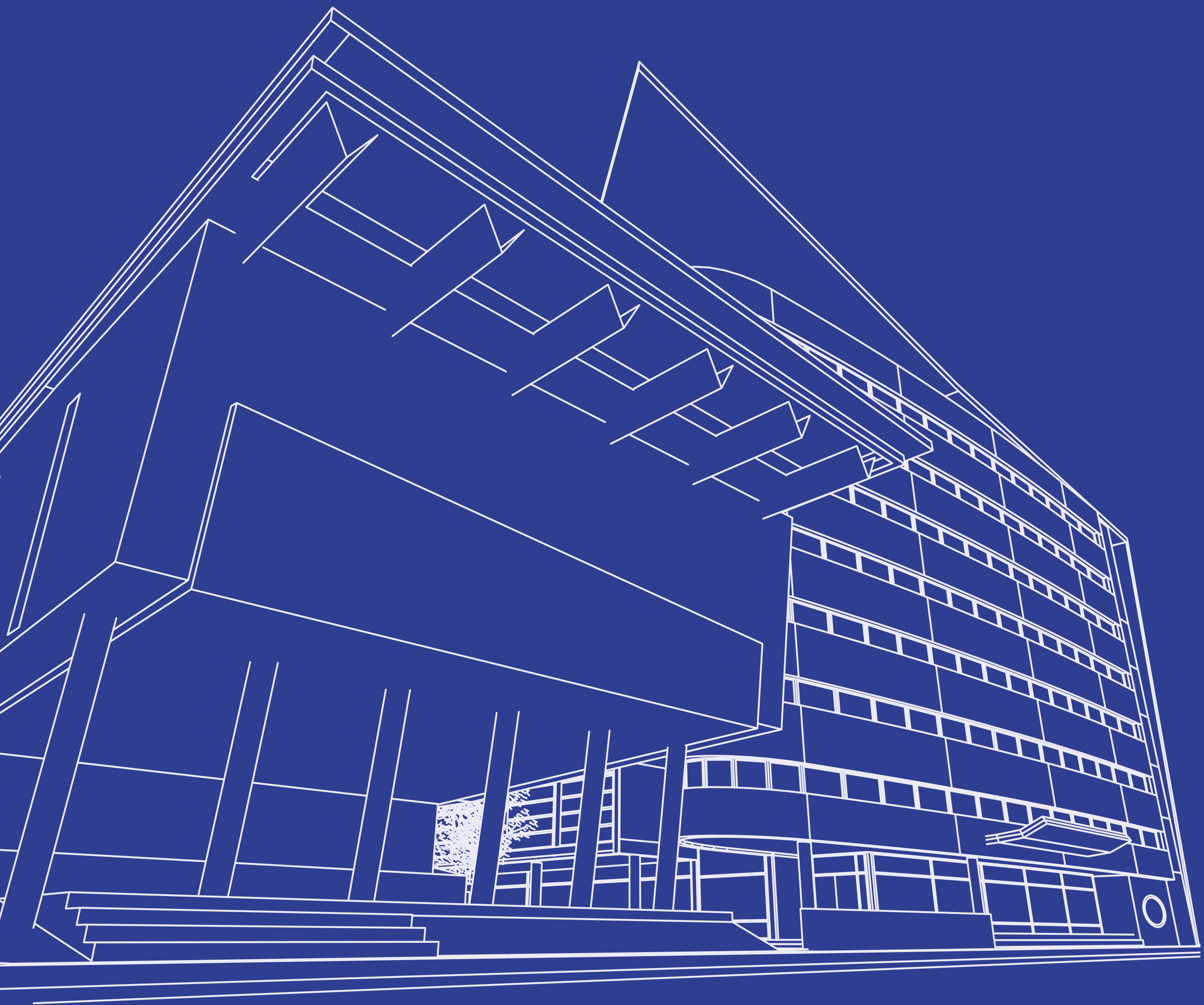
UTILISING INNOVATIVE METHODS OF DATA CAPTURE FOR REGULATORY COMPLIANCE CHECKING

Report for Industry 2020



Utilising Innovative Methods of Data Capture for Regulatory Compliance Checking

The project *Utilising Innovative Methods of Data Capture for Regulatory Compliance Checking* is led by Dr Thomas Beach from Cardiff University, which is part of the D-COM network. The D-COM network was formed to drive forward the adoption of the digitization of regulations, requirements and compliance checking systems in the built environment.

The project *Utilising Innovative Methods of Data Capture for Regulatory Compliance Checking* is supported by The Transforming Construction Network Plus (N+) which is funded by UK Research and Innovation through the Industrial Strategy Challenge Fund. The N+ unites construction's academic and industrial communities to create a new research and knowledge base, dedicated to addressing the systemic problems holding back the sector. The N+ is a joint project between UCL, Imperial College London and WMG, University of Warwick.

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Introduction

Construction regulations are designed to ensure a base level of safety and performance across the entirety of built assets. Currently formal checking of built assets against these regulations happens at defined points in their lifecycle. Based on findings from the D-COM, which identified that checking on as-built assets is a key element of the roadmap to achieving widespread digital compliance in the UK construction sector, this project begins to the exploration of this concept. It focuses on the performance of compliance checking continually across a building's lifecycle and the feasibility of using off the shelf hardware to achieve this.

The main objective of this project was to determine if "off the shelf" data capture technologies could automatically, or semi-automatically, monitor the compliance of built assets and mitigate the risks associated with their operation across their entire lifecycle.

This work has the potential to increase productivity and save staff time for building owners by increasing the number of inspections that can be done in a given period of time and by automating the processes of collecting and analysing inspection data. Furthermore, in cases where fully automated assessments are not possible, on-site data can be collected and assessed remotely, reducing travel and other time-consuming activities. This opens the door to enable building owners to deal with increasing regulatory requirements while mitigating financial impact.

This report is intended for built environment professionals with an interest in digitised compliance process. In particular; facilities managers, consultants and designers as well as professionals working in the definition, management and operation of compliance processes.

Whole-Lifecycle Compliance

As part of the project, we first coined the concept of *whole-lifecycle compliance checking*. We define this as the process of continually checking and reporting on the compliance status of a building throughout its lifecycle, in a scalable and cost-effective way.

This includes:

- Continuous Checking, continual monitoring of a building.
- Repeated Checking, less frequent checking repeated on a regular basis.
- Need-based checking, one off or infrequent checking when required.

Methodology

The approach taken through this project was to:

1. Review UK regulations to determine which areas the concept of whole lifecycle compliance checking is applicable to.
2. Consult with UK experts to ascertain attitudes, views and define priority areas.
3. Develop a series of prototypes and demonstrate their technical feasibility.

Studying the UK Approved Documents

The entirety of the 15 UK approved documents was reviewed. From this, a total of 69 candidate regulations were identified.

A further technical feasibility analysis was then conducted. Based on this analysis of the 69 regulations, it was determined that 27 of them could not be further explored, e.g. due to the lack of available technology or access constraints.

This left a total of 42 regulations that were, based on a high-level analysis, feasible for further examination, these were grouped into 12 priority areas.

Selecting Prototypes to Develop

The project team organised a survey of industry experts to ascertain their views on both the industry need and the technical feasibility for each the 12 priority areas. These results are shown below:

In this table 1 represents the highest need/feasibility, while 12 represents the lowest.

CANDIDATE REGULATION	INDUSTRY NEED RANKING	FEASIBILITY RANKING
1. Monitoring building CO2 emissions against targets	1	4
2. Validating the building fabric against standards	9	6
3. Monitoring solar gains in buildings	10	2
4. Checking compliance with accessibility requirements for access into buildings	7	6
5. Validating circulation spaces in buildings are inline with designed provisions	7	9
6. Checking of accessiblity requirements for other building facilities	12	1
7. Checking presence and compliance of fire warning signs	3	2
8. Checking of fire escape route compliance	2	4
9. Building occupancy level monitoring against regulations	5	9
10. Monitoring building utilisation patterns against design assumptions	11	12
11. Measuring heating/lighting usage against design brief	6	8
12. Validation of building heath and wellbeing factors (i.e. visual comfort, air quality, etc.)	4	11

As a result, the specific prototypes focus areas were selected for examination:

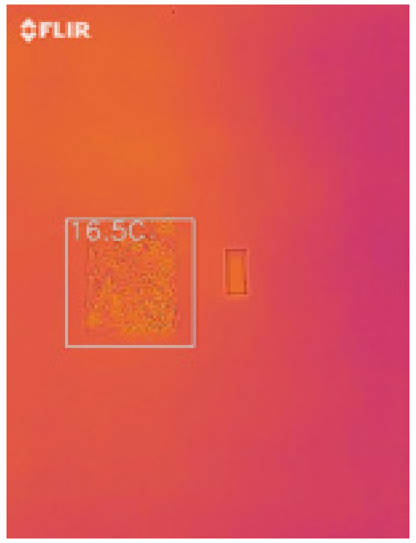
- Monitoring building CO2 emissions against targets (1), this was examined and found to be possible with current smart metering technologies.
- Validating the building fabric against standards (12), to examine this our thermography prototype was developed and tested.
- Checking of fire escape route compliance (8), to examine this our LIDAR measurement prototype was developed and tested.
- Checking presence and compliance of fire warning signs (7), to examine this our fire door image recognition prototype was developed and tested.

Thermography Prototype

This prototype aims to explore the thermal diagnostics of a typical building envelope structure to examine its thermal state. The prototype was constructed using a FLIR camera, a Raspberry Pi, an Ardunio and a set of sensors. The prototype uses thermography techniques to check against regulations in Approved Document L2AL: Conservation of fuel and power in new buildings other than dwellings.

We identified a suitable technique to obtain U-values with thermography — initial testing showed that this proved accurate enough for checking against the UK Building Regulations. The proposed method eliminates user error as much as possible by creating a single unit device for in-situ thermal images to be taken during a nightly scan (it takes more than 12 hours to undertake the scan) as opposed to a single capture walkthrough inspection. This length of time is its biggest drawback.

In the future, we aim to expand on this and develop an artificial neural network (ANN) model to predict the U-value directly or predict internal reflected temperature to calculate U-values, to test if we can obtain higher accuracy. In such a hypothesis, the ANN would provide the evaluation of the U-value in real-time. If the ANN predictions prove accurate enough, we aim to use this to reduce measurement time to less than 12-hours.



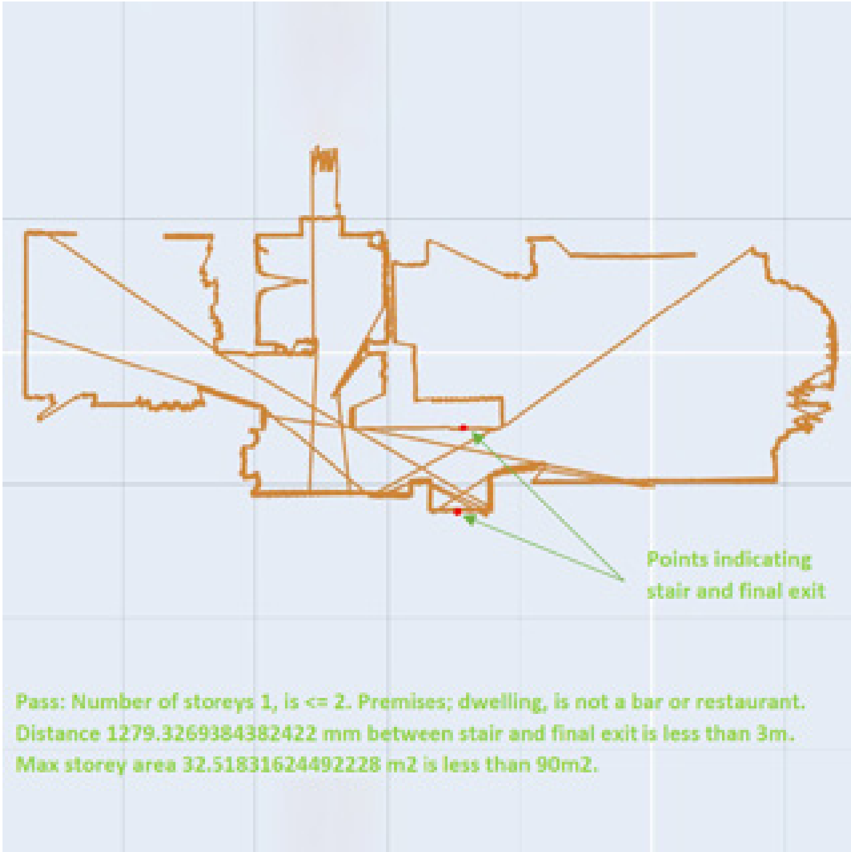
LIDAR Measurement Prototype

We developed a prototype that comprised of an RPLIDAR S1 - a low cost USB 360-degree 2D laser scanner, a monopod, and mobile phone holder, and a raspberry PI and screen.

To drive this prototype an application has been developed comprising of a Graphical User Interface, data post-processing and calculations related to the pre-selected regulations. The prototype is capable of checking 3 regulations, as a proof of concept:

- Approved Document B: Regulation 3.16 Simultaneous Evacuation
- Approved Document B: Regulation 2.10 Alternative Escape Routes
- Approved Document B: Regulation 4.8 Escape Stairs in Small Premises

The prototype functioned correctly and was able to correctly check three regulations. Furthermore, from industry feedback this prototype received very positive feedback. In particular several attendees were interested in another use for the technology – using it to construct an initial high level as-built BIM without the need for full LIDAR laser scanning.



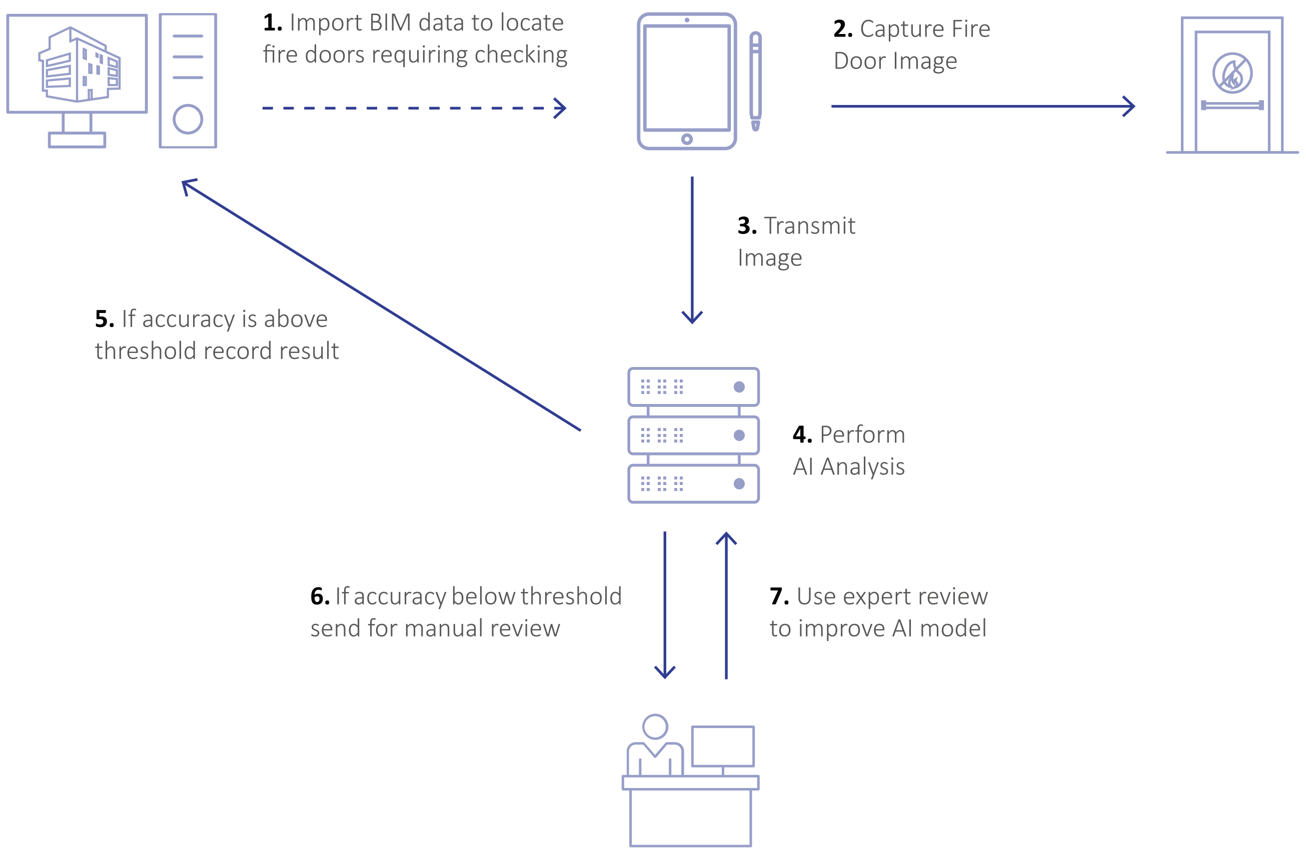
Fire Door Image Recognition Prototype

We aslo developed a prototype that included two artificial intelligence (AI) models. These AI models were designed to detect the correct signage on the fire door to fit with pre-determined suitable signs and to detect damage to the door leaf itself, which could compromise the integrity of the fire door.

Both models gave high accuracy and provided fast detection times. We evaluated the mAP (mean Average Precision). The mAP of our both of our models was between 0.9-1.0, which is an excellent level of accuracy.

This prototype demonstrated the technical feasibility of the approach for assessing fire doors automatically with a high level of accuracy.

The illustration below shows how the prototype operates, and how expert review can improve the model's accuracy even further.



Business Models

At the end of the project we held a final event to review all the prototypes. We also asked industry experts to discuss viable business models for these technology. A set of 4 key findings were reached:

- Regulatory – wherein data capture and compliance checking are conducted by building regulators, or their contractors, to check compliance.
- Preventative – wherein data capture and compliance checking are conducted by building owners to ensure they meet compliance requirements.
- Reporting – wherein data capture is conducted by building owners but is submitted to regulator for compliance checking.
- Consultancy – it is also our view that the adoption of this concept will cause a rise in the number of consultancies operating in this area, performing compliance checking duties for both building owners and possibly regulators. Additionally, it will allow existing consultancies to expand their practices enabling them to perform their activities more efficiently.

These four models provide a range of options for further exploration and testing.

Conclusions

This project has shown that the use of “off the shelf” hardware can be a means for monitoring the compliance of built assets and mitigating the risks associated with their operation across their lifecycle. Specifically, this has been shown by our development of three prototypes (all of which cost less than £600) to successfully and accurately perform compliance checking on selected aspects of the UK approved documents.

It is our view that the outputs from this project have the potential to achieve the following impacts:

Saving time and costs; by increasing the number of inspections that can be done in a given period of time, through automating the processes of collecting and analysing inspection data. Furthermore, in cases where fully automated assessments are not possible, on-site data can be collected and assessed remotely, limiting travel and other time-consuming activities. This includes:

- Allowing higher frequency checking of more areas of building performance than previously possible.
- Reducing the expertise needed and the time taken to perform this checking.
- Enabling building owners to deal with increasing regulatory requirements while mitigating financial impact.

Reducing emissions; by enabling the provision of enhanced, more cost-effective, insights into building performance for building owners. This will allow building owners/operators to intervene sooner when underperformance is identified.

Increasing whole-life value: There are a variety of less tangible measures of whole-life value of a built assets that this project will contribute to:

- Allowing a greater confidence in a building’s continued compliance with regulations. This is achieved through allowing more frequent checking of more areas of building performance than previously possible.
- This increase in checking also enables enhanced, more cost-effective, insights into building performance for a variety of stakeholders.

All of these enable building owners/operators to demonstrate increased transparency and auditability. Auditability can be achieved through the generation of an audit trail generated as part of the process of continued checking. Transparency though the ability to publish and openly release compliance data. In an environment when increasing attention is placed on building compliance, both of these add significant value to assets.

Improve the health and safety of the end users of buildings; by enabling building owners to operate a more rigorous safety inspection regime on their buildings without the major cost implications that would otherwise have been present.

Recommendations

Following the work done in this project, it is our view that, in the future, automated and semi-automated data collection has great potential to ease the burden of achieving regulatory compliance checking. While the prototypes developed in this project are still at an early stage, they have demonstrated some concrete steps that can be taken more immediately to make meeting compliance goals more efficient. Specifically these are:

- Examine ways in which compliance data can be captured digitally- even if the collection process itself is manual. Having an organised digital repository of compliance data will be invaluable because building owners are increasing being called upon to build a “golden thread” of their assets data.

- Once this is established, where possible, attempt to automatically collect compliance data using sensors and other technologies, because this paves the way for automated or semi-automated assessment.

- If automatic collection of data is not possible, consider ways in which the process can be conducted by semi-automatically or manually, but by individuals that are already on site. Moving to a model where the data collection and assessment of the data are distinctly separate. This makes more efficient use of those able to assess compliance results and generally improves productivity.

If you are interested in finding out more about the research and the prototypes, please contact Dr Thomas Beach: beachth@cardiff.ac.uk.