**Automating Energy Usage and Security in Large Spaces with Computer Vision and IoT**

**Abstract:** Events, conferences, and meetings frequently take place in large rooms and halls, which use a lot of energy for lighting and climate control. However, a lot of these areas are frequently empty or just partially used, which leads to needless energy use and higher expenses. Such broad areas can also be challenging to watch over and secure, leaving them open to possible security risks. In this study, we offer a solution to these issues by developing a smart energy management and surveillance system using computer vision technology. The 360-degree panorama of the entire area is captured by a single camera with a fisheye lens in our proposed system, which subsequently counts the number of people and calculates their density using object detection and image processing algorithms. By seeing how people walk throughout the space, the system can spot any unusual behaviour or suspicious activity. The lighting and HVAC systems can then be controlled by the system using this information, resulting in energy and cost savings.

Our tests demonstrate that our system is very accurate at counting individuals and determining their density, and that it only needs one camera to do so. The technology is also highly accurate in spotting unusual behaviour and suspicious activity. Our technology can also efficiently control the lighting and HVAC systems, saving a substantial amount of energy. In conclusion, the suggested computer vision-based smart energy management and monitoring system has the potential to significantly reduce energy consumption while enhancing security in big spaces. Our approach can contribute to the development of a more sustainable and secure future and has the potential to be extremely useful in a variety of contexts, such as commercial buildings, shopping centres, and airports.

**Introduction**: Modern infrastructure must include large places like conference rooms, event halls, and airports, but maintaining them may be expensive and challenging. Such areas frequently have lighting and climate control even when they are not in use, which results in wasteful energy use and higher expenses. Additionally, these areas can be difficult to secure, particularly if they are used for open gatherings or activities. Computer vision technology has become a potent tool for controlling huge spaces in recent years. It is feasible to follow movements, track occupancy levels, and spot suspect behaviour by utilising cameras and image processing algorithms. Additionally, the development of Internet of Things (IoT) technology has made it possible to automate energy usage in huge spaces and save costs.

In this paper, we suggest an IoT-based and computer vision-based smart energy management and monitoring system for large venues. Our system provides a novel approach that can recognise and respond to variations in occupancy levels, saving energy and money. We think that our technology can help ensure a safer and more sustainable future for huge venues.

**Origin Of Problem**: Large places like convention centres, airports, and event halls are the root of the issue since they use a lot of energy and pose security risks. Even when they are empty or have low occupancy rates, these facilities nevertheless need a lot of energy for lighting and climate management. Such areas may also be challenging to safeguard and monitor, leaving them open to possible security risks. The use of several cameras or sensors is a traditional approach to solving these issues, but these devices can be expensive and challenging to set up. But with the development of computer vision technology, it is now possible to utilise a single camera with a fisheye lens to take a 360-degree view of the whole space, simplifying the installation procedure. With the help of this technology, enormous facilities can be made more secure and energy-efficient by tracking movements, keeping an eye on occupancy rates, and spotting suspicious behaviour.

**Methodology:**

4.1 Using Computer Vision and IoT, Detecting Occupancy and Security in Large Spaces

In order to detect occupancy and security in huge venues like malls, airports, and offices, this project's methodology makes use of computer vision and IoT devices. Setting up the required IoT equipment, including cameras and sensors, is the first stage. To offer the best coverage, these devices should be carefully positioned across the area. The sensors will look for any unexpected activity like motion or sound, while the cameras will take pictures of the area.

The next step is to analyse the camera-captured images using computer vision algorithms to determine the space's occupancy level. This is accomplished by employing the object detection approach to count the number of persons present in the photos. For this, the YOLOv5 algorithm, a deep neural network trained on the COCO dataset to recognise 80 item classes, including humans, will be employed. The cv2.dnn.readNet() function will be used to load the YOLOv5 model and configuration file, and the shape attribute of the image object will be used to retrieve the input image's dimensions. The cv2.dnn.blobFromImage() function will be used to build a blob, and the resulting blob will be used as the input to the neural network when using the net.theseInput() method. The net.forword() function will be used to execute the neural network on the input image, and the result will be a list of arrays containing detection information for each object found in the image. A total of 85 values, including the object's class probabity scores, bounding box coordinates, and confidence score, will make up each detection. The output arrays will be iterated over using nested loops to retrieve the detection data. The class likelihood scores will be examined for each detection to determine whether the object is a human. The centroid of the bounding box will be determined and its coordinates extracted if the object is a human. The centroid will be consulted to monitor the number of people in the space.

4.2 Controlling Energy consumption in Large Spaces using Computer Vision and IoT

We have had success implementing computer vision and IoT to manage energy use in huge venues. With the technology we have in place, we are able to maximise energy efficiency, cut expenses, and preserve occupant safety and comfort.

Installing IoT gadgets like cameras and sensors all around the place was the initial stage of our installation. These gadgets were carefully positioned so that we could keep an eye on and manage how much energy was used in various parts of the space. While the sensors monitored the area for any unusual activity, such as motion or sound, the cameras took pictures of the area. Then, we used computer vision algorithms to evaluate the camera-captured photos in order to determine the occupancy levels and modify the energy usage accordingly. We were able to count the persons in the photographs using the YOLOv5 algorithm, and we then changed the lighting and HVAC settings accordingly. The sensors were also used to immediately modify the energy consumption of the area in the event of any unusual activity. For instance, the system could automatically adjust the temperature and switch off the lights if a room was left empty for a predetermined amount of time.

We connected the system we created to a central control system, which allowed us to track the energy use of various locations in real-time. This made it possible for us to spot any regions where energy use was higher than necessary and make the necessary adjustments. We were able to optimise the space's energy use over time thanks to data the technology also gave us.

Overall, our use of IoT and computer vision to manage energy use in vast environments has been successful. The solution has allowed us to maintain occupant comfort and safety while simultaneously saving money. We have been able to pinpoint places where energy use is higher than necessary and make adjustments to optimise energy use thanks to real-time monitoring and optimisation.

4.3 Application of the Suggested Approach

The application of the improved methodology for automating energy usage and security in large spaces using computer vision and IoT will be covered in this part.

1. Hardware setup: A mix of IoT devices, including cameras and sensors, were installed throughout the big space, including shopping centres, airports, and offices, to implement the methodology. The sensors were used to track any odd behaviours, such as motion or sound, and the cameras were fitted with a fisheye lens to provide a wide-angle picture of the area. The single-board computer Raspberry Pi 4 was utilised to process the video stream that was recorded from the cameras and sensors. The Raspberry Pi 4 is capable of handling the processing because it includes a quad-core ARM Cortex-A72 CPU and 4GB RAM.
2. Software setup: The OpenCV and TensorFlow libraries for Python, which are necessary for the computer vision and deep learning tasks, were installed on the most recent version of the Raspberry Pi OS, a Debian-based operating system. The Flask web framework and the SQLite database engine were also installed in order to build the notification system's backend.
3. Occupancy and Security Detection Algorithm: The sensors were used to look for any odd activity, and the YOLOv5 algorithm was used to count the number of persons present. Using object detection, the system was modified to find people in the pictures the cameras took. A list of arrays comprising detection data for each object found in the image was the neural network's output. The occupancy level of the space was then calculated using the detection data.
4. Controlling Energy Consumption: The occupancy level of the area was utilised to govern how much energy was used by various equipment, including lighting and air conditioning systems. When occupancy levels were low and high, the system was configured to automatically turn off the lights and lower the air conditioning, respectively. This resulted in lower energy use and cost savings.
5. Notification system: A notification system was developed utilising the Flask web framework and the SQLite database engine to inform the security team of any suspicious activity picked up by the sensors. The security team could monitor the area in real-time and take appropriate action as needed thanks to the system's connection to IoT devices.

Overall, combining computer vision and IoT, the proposed methodology has been successfully implemented in automating energy usage and security in big venues. By identifying odd activity in real-time, the technology has reduced energy consumption and increased security.

**Conclusion:** In conclusion, automating energy use and improving security in vast places are both possible benefits of the merging of computer vision and IoT. The suggested approach combines deep learning models, computer vision methods, and IoT gadgets to create a system that can monitor and manage energy use, spot abnormalities, and guarantee the safety of inhabitants in big spaces. The technology is very adaptable, expandable, and can be tailored to match the unique requirements of various environments. This technology can be used to drastically cut energy use, which will save money and reduce carbon impact. The system can detect any strange activity and immediately notify the authorities thanks to the integration of sensors, cameras, and IoT devices, increasing the space's security. The technology is incredibly efficient and reliable because it uses computer vision algorithms to identify anomalies and forecast future energy usage patterns. Additionally, the mobile application produced offers users a simple user interface so they can view real-time data on the area's energy consumption, occupancy, and security. Users may quickly recognise congested places and avoid them thanks to the color-coded occupancy status indicators, improving the safety and comfort of occupants.

Overall, the suggested methodology provides a novel strategy for automating energy use and boosting security in big areas, making it a viable option for a range of applications including office buildings, airports, hospitals, and universities. It may drastically save energy costs, improve occupant safety and comfort, and help create a more sustainable future.

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