Content Oriented Surveillance System Based on Information-Centric Network

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Introduction

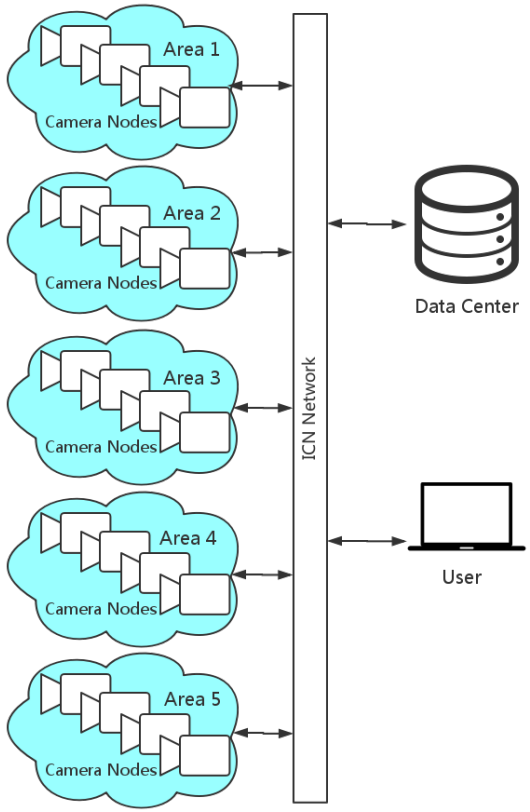
Urban surveillance systems are being applied in a rapid pace with mature but inefficient solutions. The inefficiency is revealed with two aspects:

- Too concentrated bandwidth consumption
- Too concentrated processing requirement

To solve this problem, we proposed a content oriented surveillance system based on Information- Centric Network. Instead of streaming live video to the central data center and processing multiple data stream in the same time, we have designed the nodes to process the captured raw data and produce objective contents for the subscriber.

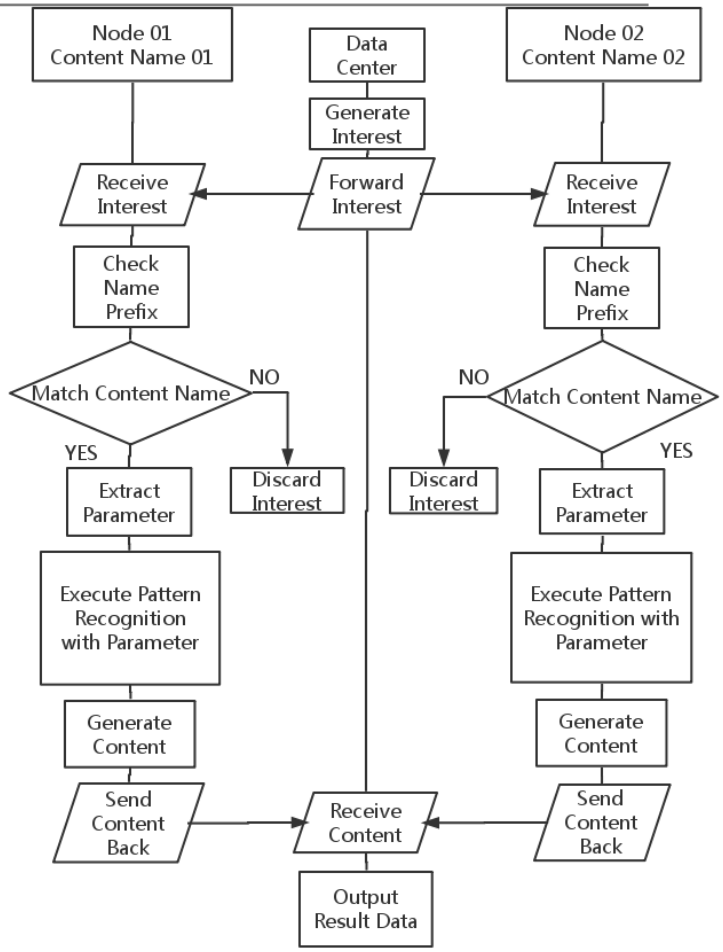
Network Architecture

This figure shows the network architecture of the method. The camera nodes were connected via ICN network and divided into several sets covering certain areas. Inside each set there was a node with control function, this node could respond to a complex request by manipulating other nodes in the set.



Network Architecture

The figure shows the flow chart of a full requesting procedure. The procedure started from the generation of the interest. The interest was a combination of the objective’ s pattern parameter and the area code for recognition. After sending out the interest to the camera nodes covering target area. The camera nodes would instantly start to analyze the fresh captured frame with the given pattern parameter, then generated the result data to be transmitted back.



Application Architecture

The user, for example, could instruct the consumer application to send a request for the human count in area one, containing 4 nodes. An interest was generated by the application and sent out. Once the interest hit a matching control node, the control node would instruct all the nodes in control (including itself) to gather and integrate information with different interest combination, then sent the content back.

Application Architecture

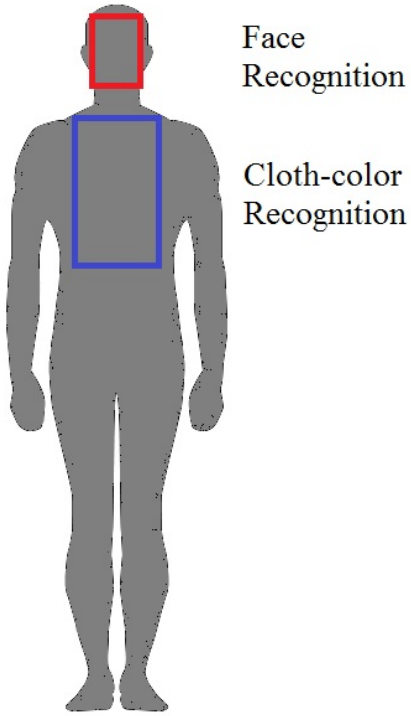
We applied two kinds of parameters to the pattern recognition application used in the experiment. They were face counter and cloth-color recognition based on open source software, OpenCV. During the analyze of the application, first it located the face areas of possible human appearances in the captured frame. While counting the value of the face number, it located the upper body cloth areas right below every face area. By summarizing the area pixels' color value, output the face count and cloth-color data together or separately. Algorism 1 describes the pattern recognition procedures.

Algorithm 1 Pattern Recognition Procedures

```
1:  INPUT: Parameter
2:  Decode Parameter to Face-count = "FC", Cloth-color = "CC"
3:  if Face-count == "yes" then
4:      Recognize faces
5:      Count face number → value
6:  else
7:      if Cloth-color == "yes" then
8:          Locate cloth area
9:          Convert color → color
10:     else
11:     end if
12: end if
13: output value
14: output color
```

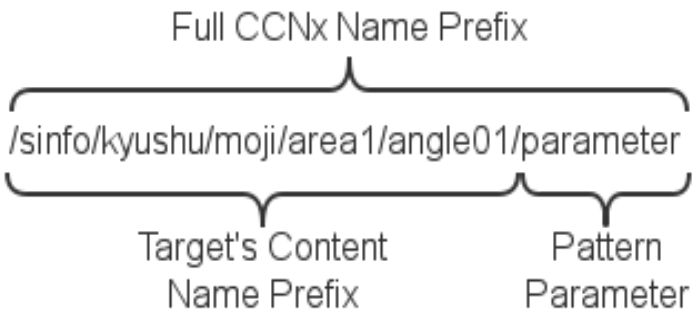
Application Architecture

On the right shows the expression of the recognition areas applied on a person. The red zone covers the face area, and below that is the blue zone, covering upper body’ s cloth area. First, the recognition application checks the execution parameter to make sure it is legal. Then finds out if it desires face counting and cloth-color recognizing. If the application is permitted to execute the face recognition function, it would quickly recognize every face in the frame and output the count value. After the counting, the application would check if there is a cloth-color recognition command. If there is one, the application would locate the area under every face and summarize the color data and then output the color data. With the outputting of the desired data, the system could reply the desired content.



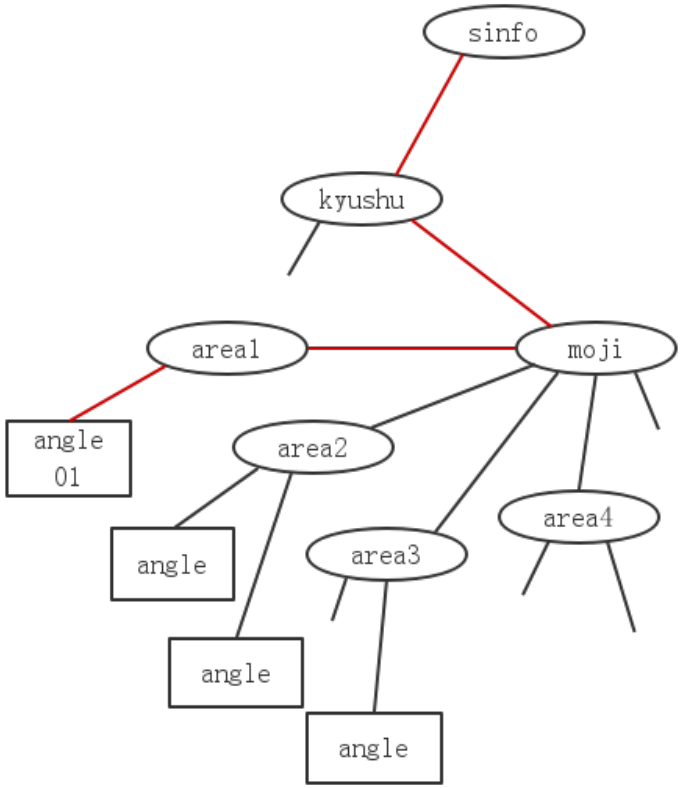
Content Naming Strategy

We used CCNx , to realize the ICN network architecture. According to the principle of CCNx functionalities, the serving application must contain a certain format of name prefix. Here we consider the name prefix as the identifier of the desired content. In order to apply different parameters to the patterns recognition appliance, the parameters were fitted into the name prefix in a certain format. This figure shows an example of the full name prefix in the method.



Content Naming Strategy

In order to manage the large scale of the camera nodes, a proper content name combination is organized. The system applies names to the contents and classifies the contents in the same time, making it efficient sorting huge amount of contents provided by the nodes, especially to human users. For example, the user could easily instruct the specific target camera node by following the system class map in the figure.



Field Experiment

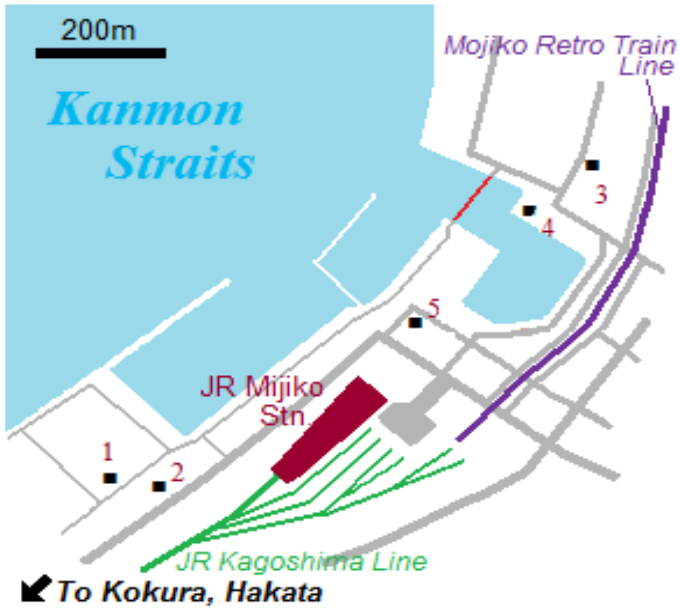
We had performed a field experiment in March, at Moji Port (Mojiko), Kyushu, which used to be an international trading port since the late 19th century.

In order to fulfill the purpose of the designed architecture. Every camera node was given certain level of processing power.

There were 20 camera nodes in the experiment, divided into 5 sets evenly and signed to 5 experiment locations referring on the right. We rented one of the facilities' room as the office that operated our experiment.

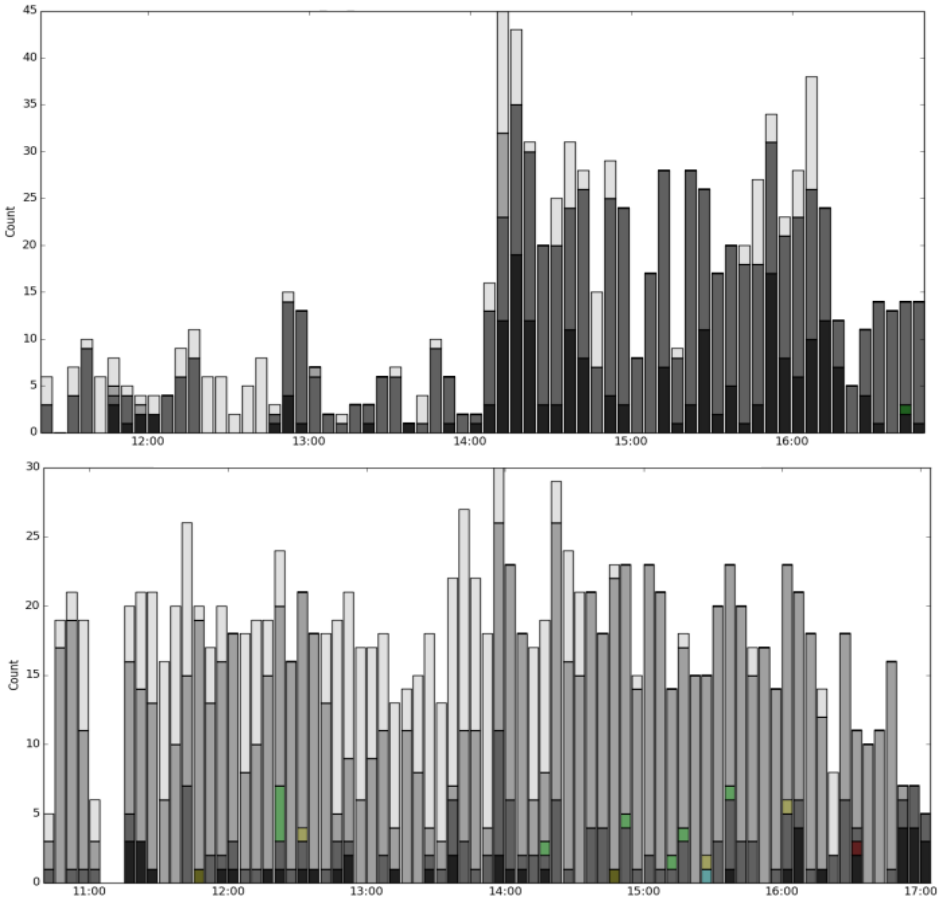
1. Kanmon Kaikyo Museum
2. Old Dalian Line Shed (Rented as office)
3. Mojiko Retro Observation Tower 1F
4. Moji Customs Building
5. Old Osaka Merchant Ship Building

Power supply	DC 5V/2A
Hardware	Intel Compute Stick STCK1A8LFC
Capture device	UVC webcam
Network device (shared by 4 units)	LTE mobile Wi-Fi access point



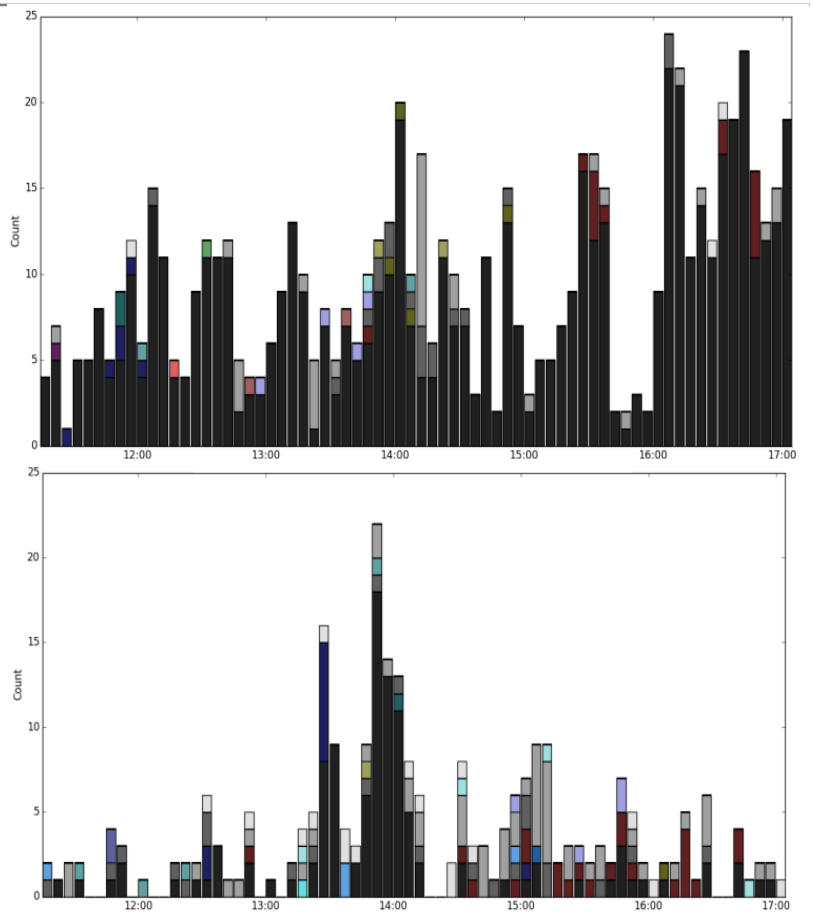
Evaluation

These figures show the experiment data of the 5 locations. The figures represented the quantity and proportion of the color of the areas, meanwhile the colored bars represented the human count.



Evaluation

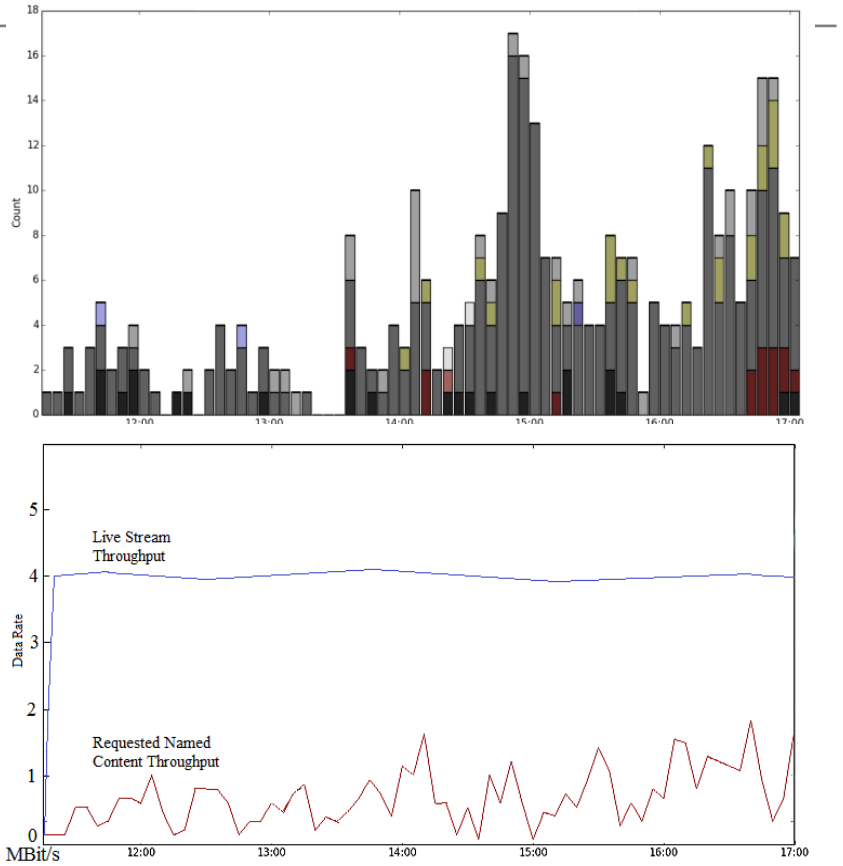
There were two major conclusions from the experiment's results based on the representation of the human counting and cloth-color. First we could easily find out the tourist's density was mainly concentrated in afternoon time except location2, Old Dalian Line Shed. This might because there were many people rented the facility's rooms on that day, including our experimenting team. On the other hand, there appeared to have most of the colors in grey, black and other dark colors. The result stands for the appearance that big part of the winter cloth choice was dark colors like grey and black, along with other bright colors in a small percentage.



Evaluation

For the evaluation of our proposed method, we analyzed the throughput from location 3. Figure shows the throughput comparing. From the figure we can see 2 throughput lines, blue and red. The blue line represents the data rate of a typical surveillance system which uses video streaming as their data feed. The red line represents the data rate from the method we proposed, the data is generated only when the target content is being retrieved. For a typical high-definition video feed, the network bandwidth consumption is around 4Mbps. From the throughput we can tell that, in a continues time, our proposed method consumes less network bandwidth than the traditional surveillance system. This is because the only contents being transferred in the network are those matches the target's interests. When the system is in idle, the whole network consumption drops to almost zero.

The compared result shows great network bandwidth save in the field. Utilizing this benefit, the system could perform very valuable in areas with low network bandwidth, also in some disaster scenarios. Meanwhile the pattern recognition appliances could work in anti-terrorism scenarios.



Conclusion

A content oriented surveillance system is proposed in this paper for the purpose of utilizing named contents in modern surveillance systems. With the ICN architecture optimizing the system performance under multiple clients subscribing. This method optimizes the network bandwidth usage and efficiently distributes processing power needs to the nodes. When there are enough nodes covering monitoring areas, it is also possible to predict target's moving pattern to foresee the next appearing location. This method could perform greatly in urban scenarios such as flow control in popular areas and anti-terrorism by evaluating people's appearances.

With the foundation of our content oriented networking architecture, more appliances, like motion detecting and sound analyzing, could be developed to utilize the ICN network. Seeing the future of big data analyzing and processing, we believe the distributed computing solution could also benefit in advance. Meanwhile the proposed method has already opened up a solution of applying surveillance system over low bandwidth network in disaster scenarios, and distributing target acquirement in anti-terrorism scenarios.

Q&A

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