Finnish Road Weather Camera System

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Introduction

In Finland, road weather information system has been gradually developed since the beginning of the 1980s. The first road weather cameras were taken into use in 1992 to complement the road weather station network. Since then the number of cameras has increased yearly – at first just a couple of units per year, recently at a pace of about 25–30 units per year. There are already 250 road weather cameras (figure 1) along the Finnish roadsides and there is need for about a hundred cameras more to cover the road network properly.

The first road weather cameras were acquired solely for road condition monitoring purposes and were directed down at the road surface. Later they have been used also for traffic monitoring, especially in the capital area, and hence are directed further, still avoiding showing skyline. The images can be utilized in professional use (traffic information centres and winter maintenance contractors) and also in public communications, for example road weather images are the most popular pages at Finnra's Internet site along with the road weather conditions pages and traffic situation information pages (http://www.tiehallinto.fi/alk/english/)

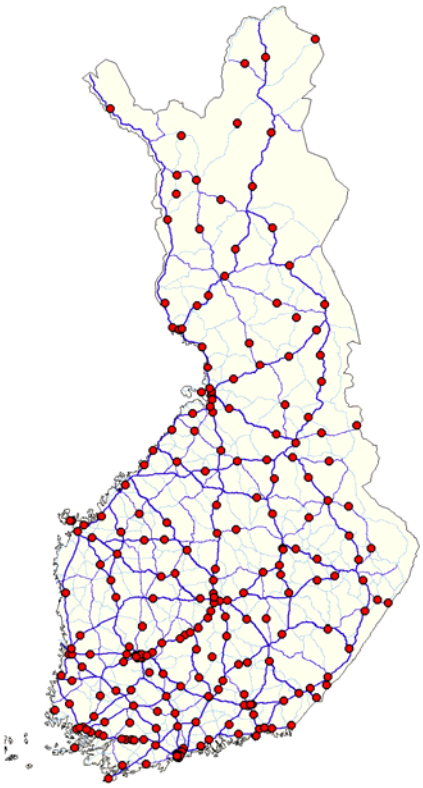

Figure 1. Finnish Road weather cameras (12/2003)

A short history of techniques used

The first road weather cameras were either colour cameras in places with road lighting, or black and white cameras with infrared light in places with no road lighting. They had fixed focal length optics and their angles of view were also fixed. The cameras had specially designed housing with heated front pane. At sites, there were ordinary PCs with modems and special video capturing cards with their own special software. They were placed in device cabinets made of stainless steel. At the office end, a PC with DOS command scripts retrieved the images with a modem. The same computers also had an application for viewing the

images. An Image Product application was introduced in the beginning of 1995 thus making it possible to view the road weather camera images also with other computers.

A need for traffic monitoring as a secondary use for the road weather cameras, rouse in the middle of the 1990s. On line connections had to be arranged to certain cameras. Thus, 'SafeNet'-concept was introduced in Finnra. The new colour cameras had varifocal lenses, pan & tilt devices and a preset positioning feature. Preset positions were made for still images – the camera was directed to a certain preset before retrieving the image. On live connection the camera could also be controlled (pan, tilt, zoom, focus) manually. A couple of starlight cameras were also tested with this system, but the quality of the images was poor both day and night. At sites, there were PCs with Integrated Services Digital Network (ISDN) -cards and special software. At the office, ISDN-cards and special applications were needed for live connections to view the dpeg stream from the cameras. The live video stream quality was quite good. The cameras accepted calls only from pre-defined phone numbers.

The data collection application that is a part of the Finnish RWIS and is used for collecting data from the road weather stations was modified to be able to collect the SafeNet road weather images.

The new video server concept for road weather cameras

The SafeNet system was not as reliable as it was expected to be, and also the development and support of the system ended at the end of 1990s, so this concept was also becoming obsolete. At the same time the demand for road weather camera images boomed, and a sustainable development had to be guaranteed.

A survey was given to find a suitable solution. The requirements for the new equipment/concept were: still images of good quality, reasonably good live stream, easy maintenance and remote configuration. Axis 2401 video server (www.axis.com) was picked for further testing and then accepted to be the new video server concept in Finnra.

Axis 2401 video servers (picture 1) support common pan & tilt devices and also preset positioning. Thus, almost any available camera and pan & tilt device can be used with them, if only all the other requirements for the equipment are fulfilled. Axis servers enable single snapshots and motion JPEG images with user controlled compression level. They can be easily configured with a web browser. Axis video server has also a relay output, and in road weather cameras it is used for invoking the infrared light.

Axis servers needed to be connected to a local area network (LAN), so there had to be a PSTN (Public switched telephone network) or ISDN router, depending on the connection type at the roadside. Also Asymmetric Digital Subscriber Line (ADSL) and LAN connections could be used, and they proved to be cost effective, especially in viewing the live stream (25 - 30 frames per second if enough bandwidth available) in traffic information centres. For live viewing the only requirement apart from the actual connection is an ActiveX component added to web browser.

Axis, besides the many good qualities, has a disadvantage compared to prior concepts: the operating temperature has to be over $+5^{o}$C. Finnish winters are a great challenge to road weather cameras' equipment in general, and to Axis video servers in particular, so heating

elements and isolation had to be added to the stainless steel device cabinets at roadsides (picture 2). Most of the old road weather camera PC's were updated to Axis in quite a short time.

Picture 1. Axis video server

Picture 2. Device cabinet at roadside

The data collection application was modified to be able to collect the Axis based road weather images. Images are retrieved from Axis video server with http-commands. Also the pan & tilt devices, as well as the infrared lights, can be controlled with http-commands, so it is possible to direct the camera to the desired direction and to invoke the infrared light before retrieving the image.

New road weather cameras

In the beginning of year 2000 there was a competitive bidding on cameras. A general agreement for acquiring cameras and optional pan & tilt devices, as well as routers and other equipment needed, was made for two years. Also a general agreement on service and maintenance was negotiated with the same vendor.

Picture 3. Testing cameras at site, 2003

Picture 4. Camera at site (device cabinet opened)

The first two year general agreement expired in 2002 and again a competitive bidding was arranged. This time the basic technique was already fixed, so the attention could be fully focused on quality and properties of the cameras, optics and pan & tilt devices. It was especially important to ensure good image quality in poor lighting conditions. Also the matter of the housing being waterproof and sufficiently heated was of consequence.

The tenders and their products were compared first on paper, and after that the best four cameras were chosen to be taken into a field test. The cameras and the pan & tilt devices were tested for a fortnight in winter in different weather and lighting conditions (picture 3). The camera that was finally chosen was superior at night. On daylight all the cameras tested produced images of almost equal quality.

Picture 5. Old camera with infrared light

Picture 6. New camera with infrared light

Placing the road weather cameras

The road weather camera images are primarily for road maintenance use, observing road conditions and weather by road maintenance contractors and in traffic information centres (TIC). Also the traffic monitoring use of the cameras in TICs is becoming more and more important. Keeping in mind those main purposes, the road weather cameras are placed on the road network

- to complement the road weather station (RWS) network with cameras,
- to help maintenance in special places (e.g. slippery hills, special micro climates),
- for traffic surveillance (bypasses of cities) and
- equal treatment of contractors (there should be some road condition monitoring devices in every contractor's area)

Electricity is obligatory and also some form of telecommunication, be it fixed or dial-up. The cameras can be installed on lamp posts or portals, also specially built steel masts are commonly used. The camera is normally installed about eight metres above the road level. The height can, however, vary quite a lot depending on the site, the height of the neighbouring light poles etc. It is good to place the camera as high as possible, so the car headlights will not blind the camera so easily. A slight uphill angle of view is beneficial for the image. The cameras should preferably be installed at places with road lighting, but also infrared lights have been and will be used. Fortunately, the new cameras work well with infrared light.

The first fixed cameras were directed down to observe the road surface (picture 7). Nowadays the cameras are directed higher, in the lower part of the image one can see clearly the road surface, and the upper part of the image shows the road a bit further and also the traffic (picture 8). If the camera has pan& tilt device and suitable preset positions are made, it is also possible to get images from more than one preset position, for example east, west and road surface.

Picture 7. Observing road surface

Picture 8. Observing road surface and traffic situation

Collecting images

The data collection has been decentralised to road regions in order to keep the telecommunications costs lower. There are nine servers around the country to collect the road weather station data and the road weather images using PSTN and ISDN lines, so no trunk calls are necessary. ADSL connections have also become reasonably priced and widely available and used.

The frequency of collecting images can be varied automatically according to weather, thus adding the cost-effectiveness. The computing application, that is used to calculate the recommendations to the variable speed limit signs, can also calculate the suitable collecting frequency for the road weather stations and road weather cameras. The equation is based on data from road weather stations, and the worse the weather is, the more often the images are collected. The collecting times vary from 15 to 120 minutes, 15 minutes being used at extremely bad weather and 120 in summer time. The ADSL and LAN cameras are collected at 10 or 15 minutes intervals at all times.

The collecting servers transfer the images to a central file server, from where the images can be retrieved for different purposes. Images are saved on the server for two days and then deleted. There are no image archives, because of the great volume of the images - roughly 1 GB daily. Developing an archiving system is in the near future plans.

The road weather images are available to road maintenance contractors and TICs - as well as all Finnra employees - via Web Road Weather application that taken into use in autumn 2001. The images are also available to the public at Finnra's Internet and are very popular - almost ten million page loads every month. Finnish broadcasting companies show road weather

images on their weather forecasts on television to illustrate the road weather conditions in different parts of Finland.

There can be only one connection to a road weather camera at a time when using dial-up networking, while ADSL connection allows several concurrent connections. The possibility to view live stream from the road weather cameras has been limited to TICs, thus ensuring that the still images can be collected reliably. The problem can be solved also by using dial-on-demand routers. They can handle several concurrent connections to the same camera through one dial-up connection. These routers are already in use in three road regions and will be taken into use in all the road regions. The routers make it possible also to swap the collecting server with no extra telecommunications costs in case of server break down, or even to centralise the road weather image collecting.

Future plans

For half of the year the most northern roads in Finland are covered with thick ice and snow. Therefore the road weather stations may not be fully made use of. There is already testing of a light RWS going on. The light RWS could then be attached to road weather camera's Axis server and the data could be collected with the image. For example, air temperature, wind speed and direction and rain measurements added to the road weather image could be the next step.

Finland is a large and sparsely populated country with long distances. Sometimes it is too expensive, even impossible, to build telephone lines to places where road weather cameras would be needed. GSM data has been tested for such places, but it is too expensive and too unreliable. There would be need for reliable and cost-effective wireless data connections for cameras. One possible solution could be General Packet Radio Service (GPRS) network that is already being tested on collecting road weather station data and automatic traffic counter data.

The quality of the road cameras and the road weather images will continue to have a high priority in developing the road weather camera part of the Finnish RWIS. Also the acquisition processes of equipment and maintenance will be further developed, and possibilities and techniques for image archives explored.