Pipeline right-of-way remote inspection system

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Abstract: - This article deals with the development of a remote inspection system for the oil and gas pipeline right-of-way. The system is designed to receive data's from various electronic equipments like IR camera, video cameras and GPS operating at different frequencies and integrate the data's for obtaining useful information. Special software for determination of variations on monitored right-of-way surface is designed. This software allows us to carry out comparison on the computer the terrain video and infrared images that were obtained at the same time and also the video images that were obtained at different times for continuous monitoring.

Key-Words: - Right-of-way, camera, pipeline, remote, inspection.

1. Introduction

European organization for environment, health and safety (CONCAWE) collects data from all the oil company operators after each incident. On the basis of the collected data CONCAWE have concluded that, 33% of spillages in West European pipelines between 1971 and 1995 are caused by third party. Moreover, net volume of oil spilled was 49%. This was because, the third party damage is usually by impact leading to larger ruptures to the pipelines, and consequently resulting in heavy loss before the pipeline can be shut down [1]. First of all, it is caused by excavation or building on a pipeline zone without the knowledge of the corresponding organizations.

For avoiding these type of incidents in all countries there are norms that establish the minimum requirements, which must be strictly executed for regulation, inspection and servicing the right-of-way with the final purpose of the pipelines safety, integrity and their proper operation. Depending on the diameter of the pipe, the right-of-way width average varies from 10 to 25 meters. If some pipes are located on the same route, the width of right-of-way is augmented. Particularly, in the paragraph No. 9 of the Mexican Official Norm No.03.0.02 “Pipelines Rights of Way of the Fluids Transportation" establishes:

9.2 According of the characteristics of right-of-way, of the surface topography and of the purpose that is pursued, they should carry out the following types of survey:

9.2.1 Aerial inspection

9.2.2 Inspection from the automobile

9.2.3 Inspection on foot.

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9.3.1 Aerial inspections are effected each 30 days.

9.3.2 The inspections from the automobile are realized each fifteen days.

9.3.3 The inspection on foot should be made weekly.

This implies, that the operator of pipelines must regularly (monthly) make aerial inspection of the right-of-way. But the visual observations have many disadvantages, and their results cannot be documented. Only from the subjective specification statements of the observer, the specification statement of the position of right-of-way can be compounded, which cannot be relied 100%.

The aerial filming as a method of monitoring pipeline right-of-way was applied in the different countries and at different time. At early stages the black-and-white photos and video cameras were used as the basic instrumentation for recording the images. Then, the digital cameras came in to usage and finally now, the colour video cameras have come into operation. The progress of computer engineering has allowed to considerably increasing the capacity and quality of the received data. The exact connection of the images to terrain by means of GPS, has allowed improving the quality of service considerably.

The Earth Observation Commercial Application Program (EOCAP) of NASA declared three major problems. First one should be solved by remote sensing of pipelines by means of aerial filming using digital camera [2]. The first aim is to develop a computerized system of storing and retrieving digital aerial photography of pipeline right-of-way. The computerized system provides an accurate inventory of right-of-way location and pipeline surroundings for engineering, maintenance and regulatory purposes. Also, in case of emergencies the system provides very rapid access to much needed information.

The second technical objective of the EOCAP project was to adapt a digital camera system for more routine aerial pipeline right-of-way monitoring. The third technical objective was to unite the digital aerial images with GIS system.

In other words, the main problems are receipt of images of pipeline right-of-way, recording these data in information tank and subsequently automatically processing the data's with gridding of images to terrain maps.

The use of digital aerial photography (in visual and IR band) provides an economic and versatile alternative. The images provide the locations of roads, hydrology, wetlands, cleared rights-of-way, structures, and other features.

Many monitoring applications of digital aerial photography exist for pipeline right-of-way, including general map updating, marketing, pipeline planning, and wetland delineating. Pipeline companies that handle crude and refined products are concerned with environmental damage from pipe rupture. They can use the integrated images for locating the sensitive areas and to plan access and boom placement in case of emergencies. Gas pipeline companies are required to perform annual dwelling surveys. These studies involve the determinations of dwelling densities within 200 meters of each pipeline [2].

Payload of aerial vehicle for digital photography (video camera) of the pipeline right-of-way can increase the accuracy of these regular safety-related surveys by adding one infrared camera. Why IR camera? Usually the inspection is carried out monthly and some works (for example the grubbing of ditches with the subsequent cover up by earth) executed in this interval it is impossible to detect.

The suggested system incorporates the IR camera that allows detecting concealed installations. This system can give the following information [3]:

- control of land texture above the pipeline;
- estimation of soil erosion connected with subsurface layer process;
- detect the grubbed ditches that were covered up afterwards by earth;
- thermal mapping of areas of the pipeline to measure heat leakage from subsurface layer.

2. System description

The system that was designed in Mexican Petroleum Institute contains the following modules: an infrared camera, video camera, GPS, data storage module and processor. Fig. 1 shows the system block-diagram.

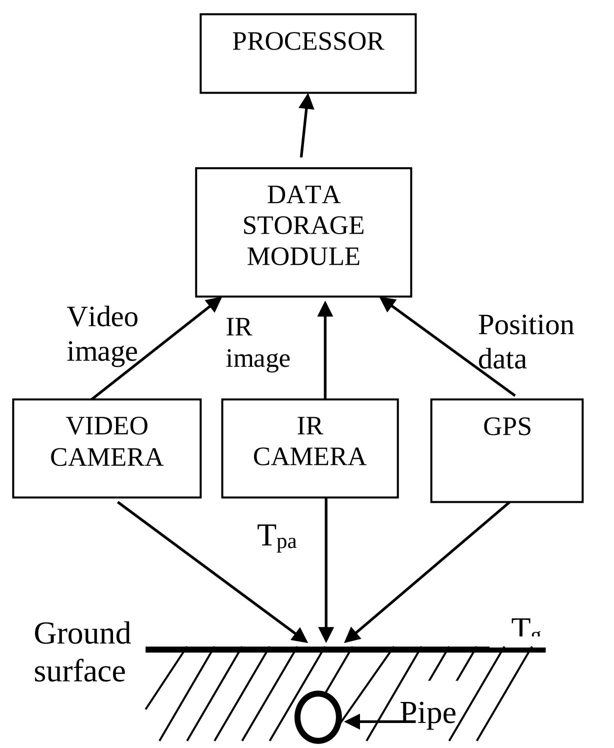

Fig. 1. System block-diagram

The principal equipment of the system is the infrared camera. This camera detects the thermal anomalies. The key operational characteristics of the IR2000 Infrared, Inc. infrared camera include: uncooled ferroelectric detector (320*240); 7-14 microns spectral response; detect sensitivity of <0.1°C; video update rate 30 Hz; EIA RS-170 NTSC video output and RS-232 serial port; dimensions 240*100*100 mm with weight 1 kg.

The detected thermal anomalies may not be always associated with third party damage, because these can be generated by means of the atmospheric thermal anomalies also. Sometimes this can cause some false alarm. Therefore to decrease the detection time and to increase the reliability of inspection the infrared onboard equipment data must be supported by information from the video band devices. Hence as additional equipment for the system, Sony video camera is used. The GPS receiver "GARMIN GPS 35 TracPak" provides position data for system. GPS data are received from a GARMIN GPS 35 TracPac 12 –channel receiver which is housed in a black, water-resistant case and designed to withstand rugged operation conditions. While the GPS 35 TracPac is designed as a "plug and play" GPS solution, the minimum system must provide a source of power and a clear view of the GPS satellites. The system may communicate with the GPS 35 via two RS-232 compatible bi-directional communication channels. Internal memory backup allows the GPS 35 to retain critical data such as satellite orbital parameters, last position, date and time.

The received information are recorded both on the films of cameras, and in electronic memory of an onboard computer. System is designed to be operated from a helicopter. The approximate cost of all system without taking into account cost of the software is about $22.5 thousand U.S.D.

3. Data processing

For geographic binding of the obtained video images simultaneously with videos filming, the current geographical coordinates and time were recorded. Recipient GPS Gramin is working on the real time mode and by means of National Marine Electronics Association (NMEA 0183) Protocol transmitting the data to on-board computer. Such scheme of parameter registration allows receiving identification of image location every second.

The information about coordinates that are obtained from the GPS receiver is recorded in the Waypoint + format. This format is practically supported by any program of GPS navigation and control. The designed special program modulus checks the regularity of the database structure by a quantum 1 second and, if it is necessary, completes the missing data by means of interpolation.

For data transformation from DV format (which has the video camera tape) to the digital format, specialized software is used. The video images were compressed by means of different video endecs, because of the large volume of a disk space that is occupied for recording the DV files (about 10-15 Gbytes for 1 hour. The compression ratio and its formats (mpeg1, mpeg2, mjpeg, divx etc.) are defined by storable quality of the video images. It allows recording one hour of video images in a 700 MB regular CD.

For the determination of variations on monitored right-of-way surface the special software is designed. This software allows carrying out visual comparison on the computer screen the terrain images, obtained at different time. Moreover, the comparison of a video and infrared image obtained at the same time is possible. The programming was carried out in MS Visual Basic language with use of the MS Media Player modulus from msdxm program library.

The algorithm of operation of the program is shown in Figure 1 and consists of the following basic stages:

1. Loading in the computer memory two files (two files of the video images recorded at different time or one file of a video images and one file of an infrared images recorded at the same time).

2. The loading of a geographic co-ordinate's data in the co-ordinate framework No.1 and No. 2 which conform to image files No.1 and No.2 respectively.

3. The loading of a map in a raster format with binding to terrain by four coordinates.

4. Playing back of video record 1.

5. On the basis of the time dependence of video or infrared images and coordinates the location of the filming is determined from the coordinate framework No.1.

6. After the definition of coordinates of filming point in coordinate framework No.1 the retrieval of the closest filming point in base No. 2 is carried out. Retrieval criterion is the minimum distance.

7. The time of filming point in base No. 2 is defined and it is transmitted to the module for synchronization.

8. The synchronization module makes periodic synchronization of the video images by means of "back winding" of the video No. 2 according to data acting on an input of the block. User can adapt the frequency of synchronization.

9. In the map window, the program draws a map of the helicopter flight path.

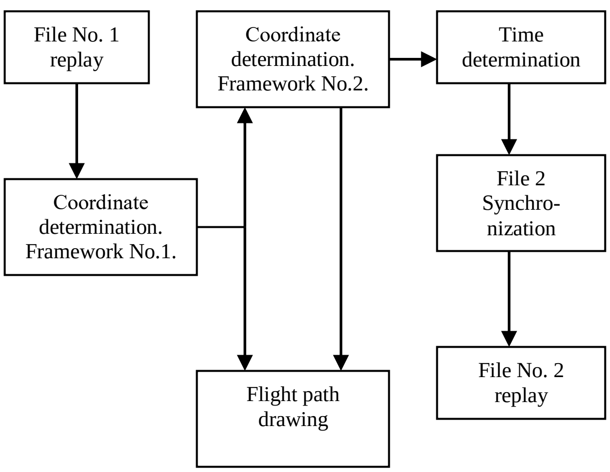

Fig.2. Block-diagram of the algorithm

The various flights not always pass precisely under the same path. Always there is some small deviation by coordinates between filming. It provokes some difficulties to the comparison of two files of the video images made at different time. For simplification of processing of two images the operator can determine a maximum permissible mismatch among coordinates of filming points. If it exceeds the permissible mismatch the synchronization is not made and appropriate message will be displayed on the monitor. For improvement of a coincidence of images at repeated observation the pathways of initial flight can be entered in an onboard autopilot of the helicopter or plane.

The comparison of the images is carried out by the operator by visual observation. If the operator detects some new objects on pipeline right-of-way he fixes the coordinates of this object in the report. All main function modes of a video player are accessible for work: rewind - forwards, pause, full screen output etc. The layout of data mapping windows and control buttons are shown in Figure 3.

4. Conclusion

The designed remote inspection system allows fulfilling the monitoring of the oil and gas pipeline right-of-way. The special software considerably lightens the work of operator and raises service quality and integrity. The system allows to document the inspection results and to accumulate the database. Further program development proposes the stepwise automation of the process of recognition of appearance of new objects on pipeline right-of-way.

References:

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Fig. 3. The layout of data mapping windows and control buttons.