

## REMOTE SENSING FOR PHYSICAL PROTECTION OF THE PIPELINE NETWORK ONLINE MONITORING OF CORRIDOR BASED INFRASTRUCTURE

M. A. Foroushani<sup>a,1</sup>, S. Damadi<sup>b</sup>

<sup>a</sup> Planning Dept. of Oil Pipeline and Telecommunication Co. Tehran, Iran

<sup>b</sup> Dept. Of Electrical Engineering, AmirKabir University of Technology, Tehran, Iran- sms\_damadi@yahoo.com

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### ABSTRACT

The existing service that locates invasions along a petroleum pipeline, informs an intrusion or warns about a disaster on the Petroleum Pipeline and Telecommunication corridors by using data from the Rights of Way (ROW), which is a buffer zone on each side of a petroleum pipeline. This data is called Corridor Based Data (CBD). For many years, the ROW has been traced and monitored by using vehicles. Recently, remote sensing and sensors technology has helped key-persons to monitor the large boundaries and long corridor of the ROW, by using spatial information and sensors principle respectively. The truth is that scalability and performance of this method has not yet been widely practiced. A large interval of the data acquisition is the main weakness of space borne remote sensing methods. This is due to our need for continuous monitoring and also to make the existing service more useful. Using a concept for automotive assistance and just-in-time decision making helps overcome the limitations of existing methods. The conceptual result proposes an efficient approach to the algorithm of intrusion detection. This algorithm could be divided into two parts of object detection and motion field geo-coded methods. Ground based remote sensing on the other hand, considers unmanned monitoring of oil pipeline corridor based on the literature of the relevant domains including Context Aware Systems, remote sensing, general interaction and GIS. This paper organized as following conceptual statement. In section 1, it gives definition of monitoring pipeline corridor. Potential monitoring through remote sensing is described in section 2 and talks briefly about the pitfalls of implementations, theoretical framework, result and conclusion, are discussed in section 3, and 4 respectively.

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<sup>1</sup>No 188 Gharani St. Postal code 1598995913 IOPTC Tehran–Iran, mforoushani@gmail.com ; mobile: +98 9363482314 Tel +98 66155329 Fax +98 21 66155438

### 1. MONITORING PIPELINE CORRIDOR

According to (Ranking 2006; Re-published from the CIA World Factbook By Photius Coutsoukis 2009) the properties of the pipeline corridor context are reporting as follows. Briefly, pipeline facilities show that two million and twenty thousand kilometer (2,020,000 km) pipelines are distributing petroleum to consumers around the world. In Europe, Germany has 33,000 km, Ukraine 29,000 km, France 23,000 km and Italy 19,000 km of pipeline. These countries have the largest pipeline length after Russia with 243,000 km. European countries account for 1/10 of the total length of the world’s pipeline network, while the United States of America has 800,000 km of pipelines, which is equivalent to 2/5 of the total length of the world’s pipelines. It is an arguable that the pipeline infrastructure is influenced by the environmental, social and technical objectives and accordingly, some residual impact and risks are inevitable.

According to the ASME (American Society of Mechanical Engineers), (American Petroleum Institute’s Pipeline Committee 2003) the annual report of third party damage that is caused by excavation, farming or other diggings activities is responsible for 41% of the damage from 1996 to 2000 as it shows in figure 1. The importance of the damage can be graded as follows: first, damaged by third party second, corrosion and third is equipment malfunction. The pattern of the ROW in a Geo-information map is a "buffer line".

#### A World Petroleum Pipeline Length

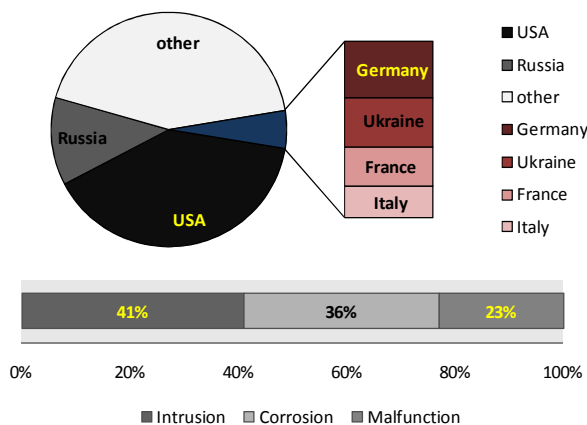


Figure 1. Damage is graded from 1996 to 2000

Figure 2 depicts the space which is allocated to operational activity, and includes a safe zone for a pipeline corridor. It aims to protect ROW from any intrusion(Enbridge Pipeline 2005 ). But knowing how to identify the threat and determining what action ought to take in order to prevent it happening again is a key component of ensuring on-going safety.

In the case of protecting approaches, The Oil Pipeline Transportation and beneficiary companies are interested to protect the transportation networks effectively by warn about intrusion. Usually, the damage is caused by other sectors. It is quite obvious, a safe operation and supervision of petroleum pipeline transportation follows a different policy from country to country or even a different Pipeline’s Profile (geo-location)<sup>2</sup>.

<sup>2</sup> - Pipeline network like river not place in certain area, thus geographical function assign to each point of ROW. It means ROW has nature of interest from point to point.

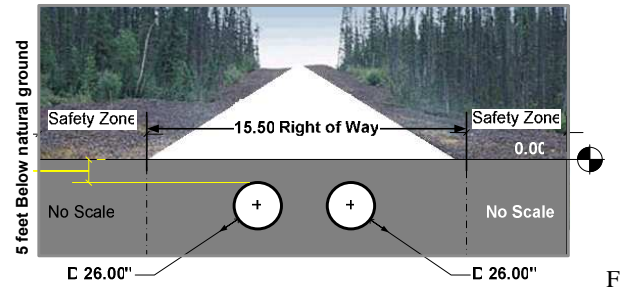


Figure 2. Right of Way Includes Area of Safety

Although the most widely used method for monitoring a pipeline network is Patrol, the other advanced application of remote sensing is also concerned. With reference to the need an application for real time monitoring of the moving object over pipeline network, space-borne and earth observation is not feasible with existing satellite. For that reason, there is no online warning about disturbance against ROW.

#### 1.1 Established methods for monitoring

Figure 3 illustrates two widespread monitoring methods. Type A shows patrol, a legacy monitoring method uses small airplane, helicopter or car in order to trace disturbance along the ROW. Each geographical direction has its own schedule to pursue from place to place. Difficulties to access mountainous locations, involving in a costly interval of data acquisition to find out what happens along the pipeline are turned into its disadvantage.

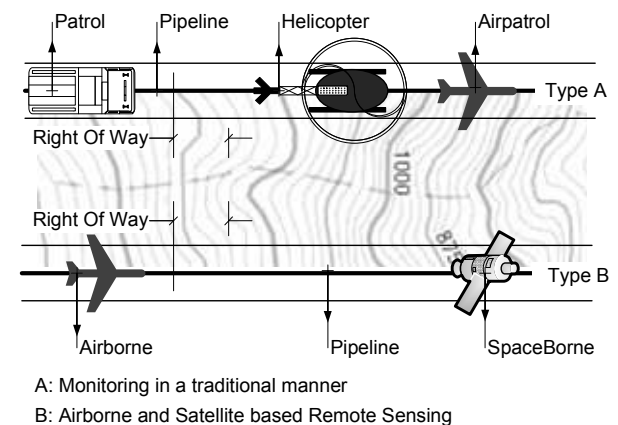


Figure 3. The Apprehensive Monitoring Techniques

Type B depicts the monitoring of pipeline corridor by new technology. Data and images have been provided by the installed scanners on the space and airborne platforms. The gathered images and data pass through the process of *Automated Classification, Noise Removal, Layer Extraction, Automated Filtering* followed by *Georeferences and Calibration of Geocoordinate System*. Final processing steps are *Data Reprocessing* and *Quality Control*. Therefore outcome help decision makers to warn about intrusions. Obviously, processing the immense number of continuous images and data makes operation too costly for the value. For this reason, high performance computer stations and GIS professional staff, enlisting the highly experienced people, special software and hardware would be involved to operate under Type B. Furthermore, a discussion of inadequacies in the current monitoring methods and present appropriate technique results from reply to impediment. Does ROW really need to

have online monitoring and why? What is the possible objective/s? Can remote sensing present the varied solution? And what is the proposed algorithm in order to improve responding to the high temporal monitoring?

In response to primary question, although observation from Patrol technique and airborne vision are appropriate steps toward the intrusion discontinued, an illegal activities may happen when patrol are moved away according to the schedule. In other words, monitoring operation is figured during a workday in below. An illegal activity is begun at 8:00 and at the same time Patrols are placed at 13:00. Patrols are far from that point thus, an unfortunate defect would be turning to disaster for company in a few hours; besides, they don't have acceptable performance in bad weather condition. Those factors proof our need to meet an online application for monitoring. Consequently, this technique could not be the best choice in order to prevent intrusion from occurring.

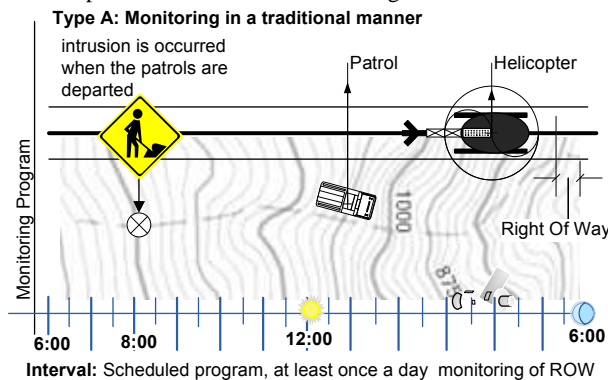


Figure 4: An intrusion is occurred after, at 8:30

In response to warning about intrusion from high temporal monitoring technique aim to fulfil the unscheduled time and enforcement action, online applications have to investigate. decision maker's choice about methods of remote sensing and its platform would be as varied as the type of pipeline construction, economics of pipeline operation, and environment in which they operate. Moreover, environmental issues and operational condition can fluctuate over the time and affect the performance of monitoring application. A few techniques relevant to the objective function are fingered by using the power of remote sensing technology.

## 2. POTENTIAL MONITORING THROUGH REMOTE SENSING

In the following aspects, potential monitoring through remote sensing and the proposed method with the objective of preventing the intrusion from occurring is discussed. Therefore candidate techniques followed by comparative table are introduced based on given importance weight.

### 2.1 Sensor platforms

In short, *Remote* as an adjective is located far away spatially, and *Sensing* as a noun is becoming aware of something via sense. Sensors are usually mounted on two platforms of Space-borne and Ground based platform. Obviously, the type of orbits and platforms determine the design of the sensors. Candidate techniques therefore are articulated based on space borne and ground based platform. Airborne scanner is omitted because of low temporal, Long Interval, inadequate number of data and limitation in flight over the pipeline's corridor.

**2.1.1 Space-borne platforms:** Satellites are placed at three types of orbits around the earth. In order to find which one suits our need, the principles of each type are briefed(UCAR 2009). The first type is geostationary. Its orbital period is equal to the period of earth rotation. So it must be placed in high attitude of 36000 km. Any sensor on this platform is viewing the same position at all time. In contrast resolution of imagery and mapping data are very coarse. For this reason, imaging and mapping satellites are not geosynchronous. Thus communication and weather purposes are the most common use of geosynchronous orbit.

The next type is polar orbiting satellite. This satellite passes above and over the earth's pole and the equator at the different longitudes respectively. Eventually, a polar orbiting satellite can see every part of earth surface within certain time period, which is highly desirable for remote sensing applications. It completes global coverage of the Earth during one day.

The third type of sensor is sun-synchronous. The satellite will pass over every location on the earth at the same solar local time. It must be placed in 700 km above earth surface. Resolution of imagery and mapping data is about 65 m as compared to a meter or less for an airborne scanner. Any sensor on this platform is viewing the same position every other weeks and months. Since active sensor rely on solar energy as a source of power. Sun-synchronous is a good choice for a space borne laser profile. Regarding to figure 5, sun-synchronized is removed from candidate method because its duration process of recurrent period. Although Geostationary can provide data and image at all time, the mention above reason makes its profile impractical and it wouldn't be feasible technique. Finally, polar orbiting satellite has been taken into consideration despite the limitation in discontinuous of recurrent period.

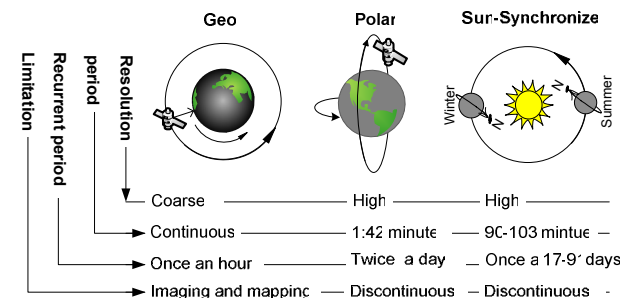


Figure 5 : A glance at space-borne scanner

**2.1.2 Ground based platform :**Terrestrial remote sensing is usually used for close-range and high accuracy applications. This system works at short, medium and long range of 50-100, up to 250 and 1000 meter respectively. Principle of short rang application is mapping building and small objects. Medium range sensor, with millimetres accuracy is using for 3D modelling application. Long range sensor frequently use for topographic application.

Three type of grand based scanning system, which are pleasing for this application are introduced. Panoramic scanner rotates 360 degree around its axis. It can also scan 180 degrees vertically. Single axis on the other hand can rotate 360 degree around its axis but scan only 50-60 degrees vertical swath. The addition of grand based scanner points on a fixed direction with limited angular range both horizontally and vertically.

## 2.2 Candidate techniques

In response to a warning from intrusion, illegalized activities over ROW will have stopped by the time the team who guards the ROW arrived over at given point. Whereas, this program is respected to scheduled program of the patrol and space- borne monitoring, there is no guarantee that a pipeline corridor equipped with a state of the art method of monitoring is protected against intrusion. Therefore, in response to the need of a continuous application, *Grand Based Platform* along with the state of the art techniques is considered. In the following section comparative technique are discussed and ranked based on the weight of the value.

**2.2.1 Comparative methods and techniques:** Table 1 highlights a number of advantages and disadvantages of candidate techniques. The column for A and B show certain similarities. There is the same rank of disadvantage for the *Recurrent Period*, *Cost to Process* and *Lack of Sufficient Staff*, in comparing with only two minor disadvantages of *Cost to Capacity* for ground based remote sensing technology and given *Time to Stop an Intrusion* from “technique C”.

| Techniques of monitoring | Customizable platform    | User Interface and | Lack of Sufficient Staff | Data Analysis & Final Report | Cost to Capacity | High Resolution | Detecting Moving object | Warn about Natural Hazard | Cost to Process | Period and recurrent Period | Concealment of Confidential area | Time to Stop an intrusion | Time to response (Push-Pull) |
|--------------------------|--------------------------|--------------------|--------------------------|------------------------------|------------------|-----------------|-------------------------|---------------------------|-----------------|-----------------------------|----------------------------------|---------------------------|------------------------------|
| C- Ground based          | Mobile based             | Sensor             | No                       | GSM                          | High             | Text            | Remote Sensing          | Yes                       | Low             | Real time                   | High                             | High                      | High-Push and Pull           |
| B- Space Borne           | Satellite&Airborne & UAV | Camera & Sensor    | Yes                      | Powerfull waives             | Medium           | Image and Data  | Remote sensing          | Yes                       | High            | Scheduled                   | Low                              | High                      | Medium-Pull Service          |
| A- Patrol, Helicopter    | Patrol, Helicopter       | Human eyes         | Yes                      | paper based Report           | Low              | Real world      | Observation             | No                        | High            | Scheduled                   | Medium                           | low                       | High                         |

Table 1. Comparative Methods and Techniques

Frequency or *Recurrent Period* defines length of time that is marked off by two observations. It is the act of observing comes back to the same area at almost same time. That is to say, a scheduled program is not provided continuous service for the company. For that reason, *Cost to Process* would make increase the expense of this process. *Cost to Process* means the money that company usually pay for a period of scheduled program. However, minimum interval would not be less than 6 to 12 hours for those candidate techniques. That is to say, “technique B” pays out a bit higher for building capacity as well as running scheduled program. On the other hand, “technique C” shows that the *Cost to Process* for real time program is arguable although the *Cost to Capacity* itself would be expensive. Regarding *The Lack of Sufficient Staff*, another weakness remarks that for both “A” and “B”. To put it another way, “technique A” always need to have on-call security and maintenance staff, as far as the requirement of professional analysts is concerned for “technique B”. Then again for “technique C” and B *Time to Stop Intrusion* is added to those

disadvantages. For a case in point of warning about intrusion over given place, how long does it take till security and maintenance staff would be there? So multiple processing must be in place with trained staff and advanced application to achieve optimum system performance and safety.

Conversely, the advantages of “technique B” over “A” are several items such as; *User Interface*, *Report Generator*, *Detecting Moving Objects*, and *Warn about Natural Hazards*, whereas with the reference to the need of notable items for the best candidate technique, some advantage are indicated. They are remarked as *Time to Response*, *Continuous Monitoring*, *Less Cost to Process Online*, *Detecting Moving Object and Needing Few Trained Staff* followed by *Customizable Platform*. In addition, *Concealment of Confidential Area* means to operate on limited area through the pipeline corridor from the level of official classification next above restricted and protected area such as; nature of interest, public awareness, historical and protected area, national park, dessert, forest, a secure place and mountainous corridor. Finally, in order to decrease the time of processing, *Push Service* would make it easy. Obviously, text processing needs as less as possible times to process. It would be an advantage to warn about intrusion at given time. To sum up, discussed parameter of the candidate technique are ranked as it shows in table2.

| Low importance = -2      High importance = 2 |                                  | Importance Rate | Patrol | Space Borne | Ground based |
|--|----------------------------------|-----------------|--------|-------------|--------------|
| High rank=5<br>Med rank =3<br>Low rank=1     |                                  |                 |        |             |              |
| Parameter Ranked                             |                                  | A               | B      | C           |              |
| Cost   | Lack of sufficient Staff         | 1               | 1      | 3           | 5            |
|  | Data Analysis & Final Report     | 1               | 3      | 3           | 5            |
|  | Cost to Process                  | 2               | 1      | 3           | 5            |
|  | Cost to Capacity                 | 1               | 5      | 1           | 3            |
|  | Customizable platform            | -2              | 3      | 1           | 3            |
| Quality                                      | User Interface                   | -1              | 5      | 3           | 3            |
|  | Period and recurrent Period      | 2               | 1      | 3           | 5            |
|  | High Resolution                  | 1               | 5      | 3           | 3            |
|  | Concealment of Confidential data | 2               | 3      | 1           | 3            |
| Time   | Time to stop an intrusion        | 2               | 5      | 3           | 3            |
|  | Time to response ( Push-Pull)    | 2               | 1      | 3           | 5            |
| Detection                                    | Detecting Moving object          | 1               | 1      | 1           | 5            |
|  | Warn about Natural Hazard        | 1               | 1      | 3           | 5            |

Table 2. Specification of candidate techniques

Those parameters are classified in *cost*, *quality of data*, *frequency* and *detection*. With reference to three techniques, technique A is weighed against both B and C which are space and ground based techniques respectively. Then again each parameter are assigned own factor between -2 and 2. Low importance is of course -2 whereas 2 present high importance parameter. Therefore important rate itself is multiplied by the given rank make score. Additionally, classified parameters are ascended from -2 to 2 as is depicted in Figure 6. The graph provides the ranking information of candidate technique. From top-down point of view, the first line (light green) plots specification of “technique C” while the second and third line (Red and Blue) show a detail description of “technique B” and A respectively. From the line graphs it can be seen that there are minimum and maximum score belonged to *Customizable Platform* in the extreme left, and *Time to stop Intrusion* in the extreme right. Maximum score reach over 10 is belong to the first line in *Time to Response an Intrusion*, *Period and*

*Recurrent Period* and *Cost to Process*. In contrast, Red and Blue (B and A) have hardly 6 in both essential parameter of *Recurrent Period* and *Cost to Process*. Then again, Green line (C) is scored slightly less than 6 in *Detecting Moving Object* and *Warning about Natural Hazard*. Whereas Red and Blue (B and A) are scored below 2 in detecting moving object in given time. All in all, “technique C” is of course much better than “technique B” and “technique A” outside the *Malfunction*, *Time to Stop an Intrusion*, *Data Resolution* and *Cost of Capacity*.

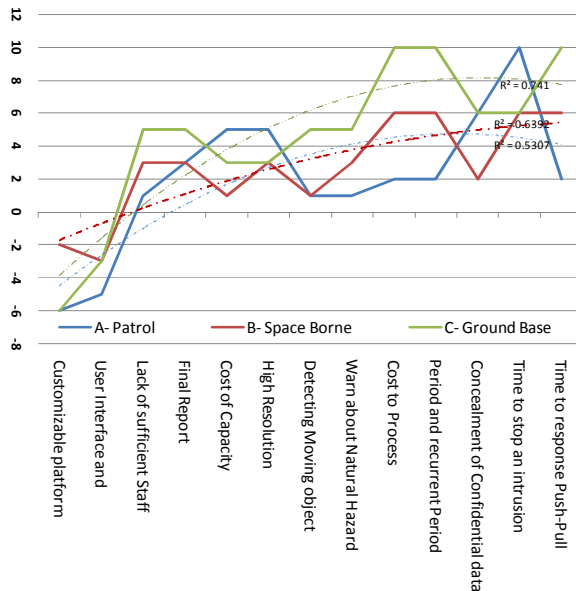


Figure 6. A quick view of candidate technique

From technical point of view, a decision to choose appropriate technique will make based on access time to the area of operation(site) in order to prevent damage from occurring, standard and a perilous of petroleum transportation, the pipeline network topology, investment and applied technologies such as SCADA, optical fibre and national infrastructure. That is to say, type C is proposed as a Ground Based Remote Sensing method (GBRS). What is more about implementation, remote sensing sensors are installed along the pipeline (ROW). These detectors are electronic devices that can sense activities against corridors in real time. Intrusion will be recognized and analyzed by utilized techniques. As an obvious benefit of push service, decision maker will received an alarm message from the point that has been threatened.

### 3. IMPLEMENTATION

The proposed model needs to support by information and data from the pipeline corridor samples per second. So, the service should respond to context dynamically. Systems can dynamically change their response because the context is categorized as various, reactive, context-sensitive and environmentally directed(Gregory, Anind et al. 1999). These models are mostly introduced in the boarder context of interaction systems. It can include the user and applications(Anind 2001). From *System Component* point of view, proposed models is to capture important system components such as *User*, *Location*, *Context* and *Data*. (Anind 2001) and (Schilit, Adams et al. 1994) introduce different contexts that are relevant to a user when accessing an information service. Localization and service are the main key-

points in *Context Processing* application. It is an information service, accessible with mobile devices through the mobile network and utilizing the ability to make use of the geographical position of the mobile device (Shu Wang 2008). According to (Nivala, A-M et al. 2003) there are nine types of context with sequential access of *Physical surroundings*, *Navigation history*, *Purpose of use*, *System properties*, *Time and Map user*, including *Social Culture* and *Orientation* followed by *Location Context*. The result of the defined context shows that *Context Processing* service targets many users and is available in a mobile-network communication environment. Eventually, the service of context is provided for both pull and push services. Since Push-Services do not rely on previous user interaction with the services. If the corridor be threatened by external factors or disasters the information messages will be received. As is illustrated in figure 7, technical based components from Type C are: *Detectors* (those could be any kind of Sensor/Scanner depending on the corridor situation, Geographical location and the application purpose), *Communication network*, *positioning technology*, and *data provider*.

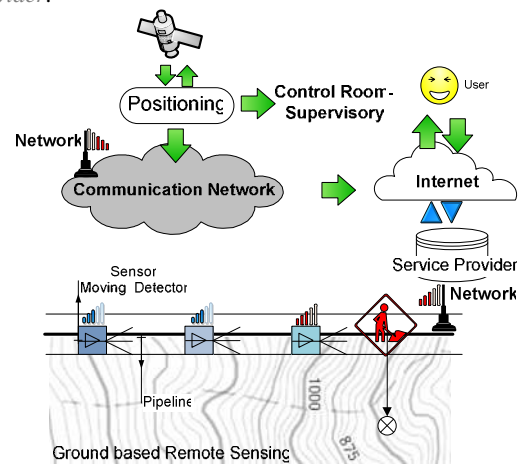


Figure 7. localization and service

Detectors, periodically report positioning information and send it all to the service providers. Obviously, the provision of the push services by such a database approach would involve a huge amount of signalling information, since the positions of all mobile devices have to be continuously transmitted to the database server and information has to be send to the devices (S. D. Hermann and A. Wolisz 2006). Supervisory and user beneficiaries can receive information through the internet with following sequential process.

If an intrusion or a disaster happens over the ROW, the actual position of the sensor/ scanner is obtained from the positioning service. Afterwards, an exact position of occurrence is sent via communication network to a so called gateway. Consequently, the gateway has the task to exchange messages among a communication network and the internet. At the same time it will store information about all the sensors. A server reads the messages and sends them to a program analyzer. Moreover, the service analyses the message and pushes it to the receiver. Then, the service will find information on whether the corridor should be under extra control. In the end, results are sent to the consumer / supervisor via an internet gateway or mobile system. Finally, proper action is taken.

#### 3.1 Theoretical framework

Regardless of the sensor technologies and scanner, a pipeline corridor can be scanned online by the ground based remote

sensing technique. Figure 8 shows top level schema of three simple steps from *receiving signal* and *extracting process* aim to detect *moving object* over corridor and to make warning about intrusion.

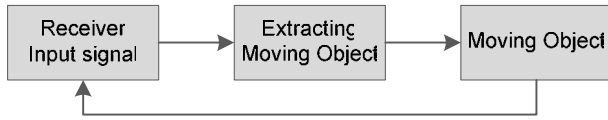


Figure 8. Top Level Framework

As it's mentioned on earlier paragraph and depicted in figure 9, receiver input signal consist of data from sensor, reference data which calls pattern data and feedback from the previous records. The next step, of the extracting moving object has three functions of revealing, de-noising and detection. This step is usually programmed based on different remote sensing application. The last step consists in the function of making warn about intrusion to decision maker, estimation and event history. Finally event history makes feed back to first step.

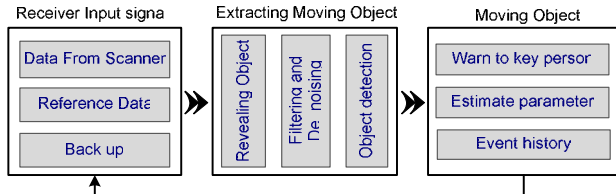


Figure 9. Classification Schema

Image and data that are gathered recently will be compared to the reference. For instance, if hardware processes just a few points (no more than 5), because there is high flow rate of data, we need a lot of time and expensive hardware. For this reason and according to the Figure 10 the problem with scanners especially LADAR is considered in three components.

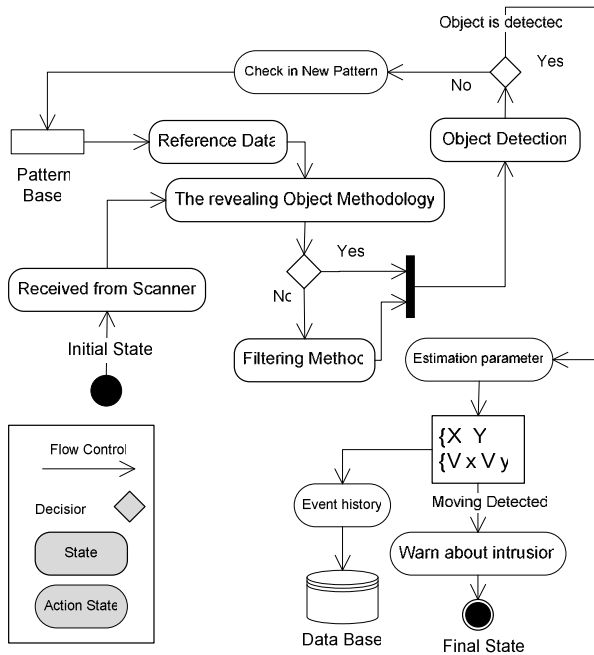


Figure 10: Process of Object Detection schema

The first component is *Classification and Filtering Process*. As far as this technique is supposed to help us to concern certain

point instead of all the point in the corridor. Figure 10 shows how *Classification and Filtering* can reduce the time to producing report and the size of its. To put it another way, system is looking for the similarities between recent data and reference. For this reason the elimination of the frequent data interaction will take into consideration. Secondly, to reduce the process time *Defining Reference* process is introduced. Additionally, *Discrimination technique* is of assistance software to match recent data with typical shape and suitable format for moving and static objects. For instance, red colour and green can assign to moving and static objects respectively. On the other hand, it is possible to identify whether it is human or device? What it looks like. Regarding to the power of code, it is also possible to recognize the dimension of objects. For the computation of optical flow of 2D image motion the following (Yokoyama and Poggio 2000) function is presented:

$$I(x, t) \cdot I(x + dx, t + dt) \quad (1)$$

Where  $I(x, t)$  = the spatiotemporal function of image intensity

$t$  = intensity of the time

$t + dt$  = **object is assumed to remain the same**

For instance; no illumination change are supposed to occur. Equation 1 can be expanded using Taylor order as follows:

$$\nabla^T I \cdot V + I_t = 0 \quad (2)$$

Where  $\nabla I = (I_x, I_y)^T$  = the gradient

$I_t$  = temporal derivative of  $I(x, t)$

$V = (u, v)^T$  = image velocity

According to the (Barron, Fleet et al. 1994) one linear equation is insufficient to determine 2D velocity that is known as aperture problem. However it seems good enough to detect moving objects. For instance, moving object on geometric shape, (such as line circle, rectangular and....), indicates intrusion activities.

### 3.2 Detecting Object

It is defined the similarity between an object of previous frame  $R_{prev}(m)$  and an object of current frame  $R_{cur}(m')$ , using estimated position of lines by optical flow.

$$\{P_1, P_2, \dots, P_n\} \in S$$

Equation (Bernhard Gruber SW. Location Based Services using a Database Federation. Institute for Geoinformation) is Detected and stored line of the current frame.

$$\{S_1, S_2, \dots, S_n\} \in R_{prev}(m) \quad (4)$$

Whereas equation (4) is defined all background line as a previous frame, then similarity is defined as follows:

$$\rho(m, m') = \frac{\sum_{j=1}^{N_m} \sum_{i=1}^{N_{j'}} l_{ij}}{\sum_{j=1}^{N_m} |S_j|} \quad (5)$$

Where  $|S_j|$  is the number of element in  $S$ , and  $l_{ij}$  then these two objects  $R_{prev}(m)$  and  $R_{cur}(m')$  are considered as the same object if the similarity of  $\rho(m, m')$  is non-zero value.

$$t_{ij} \begin{cases} 1 & \text{if } P_i \in R_{cur}(m') \text{ where } P_i \in S_j \\ 0 & \text{otherwise} \end{cases} \quad (6)$$

$$R_{prev}(m) \equiv R_{cur}(m'), \text{ if } \rho(m, m') \neq 0.$$

#### 4. CONCLUSION

Due to the fact that if an intrusive process over the ROW causes unfortunate defects, the company mission will be under threat of inconsistency operation and the oil transportation through pipeline will stop. An occurrence into pipeline also expense company too costly for the value of rehabilitation to fix damaged parts, soil remediation and keeping a safe and clean corridor from splash with oil.

From the general point of view, physical protection plays a significant role in order to having reliable operation and makes it safer. Apparently, traditional methods of monitoring program are less successful with continuous gathering data process from pipeline corridor. Consequently, it gives company low rank in quality services. For these reason, the overall performance of existing techniques are not acceptable.

From technical point of view, a decision to choose appropriate technique has been argued based on *Time to Response an Intrusion, Period and Recurrent Period and Cost to Process* including *access time to the area of operation (site)* in order to prevent damage from occurring, *standard and a perilous* of petroleum transportation, the *pipeline network topology, investment and existing technologies* such as SCADA, optical fibre and so on. With the reference to former reason, type C as a Ground Based Remote Sensing method (GBRS) has been proposed. Regarding to the cost of operation, proposed technique might be able to recognize high risk activities as well as disaster over pipeline corridor. The next obvious benefit is stopping to spend a lot for the neighbouring corridor in order to fix pollution and pay the penalties. For this reason, the cost of the injured parties adjacent to the pipeline corridor, by using GBRS will reduce. All in all the following result from this proposal is expecting if it turns to a practical profile through the ROW. Spatial Data Infrastructure (SDI) plays role as a service provider for LBS but in this concept it is Vice versa, and SDI will be getting up-to-date from Corridor Based Data.

All intrusion over pipeline corridor would be detected according to GBRS technology and its principle. Outcome of GBRS as a high spatiotemporal information can be placed in GIS layers for Geo- Corridor Based Map. So implications of the context will give consumers and users the advantages of Geo-ICT.

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\* Univ.Prof.Mag.Dr.Georg Gartner, Cartography and Geo-Mediatechniques Department of Geoinformation and Cartography, Vienna University of Technology, Erzherzog-Johannplatz 1, A-1040 Vienna, Austria, email: georg.gartner@tuwien.ac.at Tel (+43)58801 12611, URL; <http://cartography.tuwien.ac.at>

\*\* Ir. V. (Bas) Retsios, Software developer from department of Geo-information processing in ITC - Geo-International Institute for Geo-Information Science and Earth Observation-the Netherlands, Enschede. email : retsios@itc.nl

\*\*\* ILI Senior lecturer Mr. Babak Etemadi, Electronic engineering, [babak\\_etemadi35@yahoo.com](mailto:babak_etemadi35@yahoo.com)