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Algorytmy ewolucyjne z uwzględnieniem płci w rozwiązywaniu wybranych problemów

Filip Malczak

słowa kluczowe:
key words
different
can be placed here

krótkie streszczenie:
W pracy przedstawiono nową metaheurystykę ewolucyjną DSEA, uwzględniającą aspekt płci. Praca zawiera opis badań, których celem było porównanie skuteczności DSEA z rozwiązaniami znanymi z literatury.

Promotor:	dr hab. inż. Urszula Markowska-Kaczmar	....	....
	imię i nazwisko	*ocena*	*podpis*

*Do celów archiwalnych pracę dyplomową zakwalifikowano do:**

a) kategorii A (akta wieczyste)

b) kategorii BE 50 (po 50 latach podlegające ekspertyzie)

**niepotrzebne skreślić*

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Contents

Streszczenie

Mamy ściśle określone środowisko - podziemny korytarz. Korytarz jest odizolowany od fal radiowych. Jako osoba pracująca w korytarzu chcemy nasze określić aktualne położenie, mając do dyspozycji urządzenie mobilne klasy Smartphone. W korytarzu mamy możliwość zainstalowania specjalnej sieci radiowej umożliwiającej przybliżone określenie aktualnej pozycji. Należy sprawdzić dokładność określania położenia wyłącznie przy użyciu infrastruktury sieciowej (algorytm podstawowy) oraz należy zbadać możliwości poprawienia dokładności określania położenia przy użyciu sensorów wbudowanych w urządzenie mobilne.

Abstract

There is strictly defined environment - underground corridor. The corridor is free from external radio waves. As a person working in the corridor I want to determine my current position with a mobile device (Smartphone). * There is need to find and install navigation system that will allow to determine current position of mobile device in the corridor. * There is need to verify location accuracy of basic algorithm that use the navigation system infrastructure only and explore the possibilities to improve location accuracy using sensors built into the mobile device.

Chapter 1

Goals and thesis scope

Following citations are used only in purpose of Bibliography formatting test purpose: [5] and [8] and [6].

Chapter 2

Introduction

2.1. Underground installation characteristics

Description of: * Construction (very briefly): ** how can look like: from complicated (room and phillar) to simple (tunneling) ** distances ** how big it is: corridor diamensions, room diamanesions, etc. * Conditions in therms of light and air. * What wireless communication methods are available?

Answer questions: * if we need the navigation in whole installation? if yes, why? * if we need the navigation only in some places inside installation? if yes, why? * what factors may require from navigation system its extensive lifetime?

This section covers a short description of underground installations in general that are the environment for the positioning system.

Underground installation therm is a general description of places such as tunnels and shafts that were digged into the earth in purpose of valuable material extraction, transportation, touristics or other reasons. The common phase in those installations is the phase of their creation. There is a need to digg tunnel or shaft at first in order to reach buried ore deposits or just remove not needed rock. Tunnels and shafts are used in this phase to supply material needed to perform exchavation, for personel transportation and rock transportation to the surface. Mining installations are about continous rock exchavation process (creation phase) while the others, like designed for transporation, ends creation phase and moves to the phase of use and maintenance. Underground installations that can be descibed as a gorup of laneways (main and branch tunnels) and in case of mine: mining areas and mined-out areas.

What is the common in underground installation is that there are no reference objects like plants, horizon or sun. Corridors and chambers are almost identical, in particular if there is room-and-pillar extraction method used. For orientation special numbering is introduced in order to identify corridor and given meter of the corridor. Symbols are painted on the walls with reflective paint and are regurally repainted. Dust combined from moisture deposit himself on a substrate, the walls and ceiling covering symbols describing the hallways. It worsens the orientation.

As the purpose of underground installation may be different, there are also different environmental characteristics such as diamensions, type of material (rock), amount of dust, how freqent is in use, what means of communication are placed into, what machines (if any) are being used inside. Along greater depths, the work conditions are decreasing. The probability of coal and gas outbursts increases because of bigger gas emission on deeper levels. Underground installations can be affected also by water leaks, coal dust explosions and rock bursts [10]. That is why underground installations are prepared for such disasters as floods, fire, high/low pressure, presence of gas, big carbon monoxide (CO) level, or enormous amount of dust. The another risk is connected to people and material transportation. Poor light and narrow working space causes underground car accidents.

Underground mines, which are characterized by their tough working conditions and hazardous environments, require reliable underground installation-wide communication systems in order to prevent from accident if possible or provide means of early warning of possible disaster [1]. Besides safety purpose, both analog and digital communication is used in order to ensure smooth functioning of workings. For example it is possible to save the machine breakdown time thanks to immediate messages passing from the vicinity of underground working area to the surface for day-to-day normal operations.

With respect of the areas of the underground working activity there are different communication system used. Communication technology in underground installations use wired transmission media (twisted pair, coaxial, trolley, leaky feeders, and fiber optic cables), wireless and through-the-earth (very low frequency radio methods) transmissions. In most cases the communication solutions are based on wired technologies. Wireless communication techonologies are used in places that are inaccessible or in places affected by disaster where wired communication got broken. It is also havily used for communication purposes with modern underground equipment such as self-propelled mining machines. Wireless communication is installed also in underground installations where probability of disaser is low as an extension to wired technology. Commercial tunneling equip thier corridors with wireless communication technologies such as GSM and WiFi in order to speed up communication between executives on tunel construction site and on surface. Tunneling is about digggin a corridors for transportation purposes in difficoult terrains such as mountains or bellow the water. Operations that are performed it high latitudes where gas is not present are safer then in mines which operates deep under the surface.

*** The wireless communication systems used on surface cannot be applied straightaway in underground mines due to high attenuation of radio waves in underground strata. Undergorund radio waves propagation envioronment differ also because of

- presence of inflammable gases,
- hazardous environment,
- complex corridors topology (mines case),
- complex geological structures,

2.2. Usage of mobile devices in underground installations

* Define 'mobile device'

Answer questions: * If mobile device (smartphone class) can be used in undergorund installations? * How usage of mobile device in underground installations may differ from usage in normal conditions (outside underground installation)?

2.3. Navigation system use-cases

* Introduce 2-3 ideas with visualizations

CASE 1 Mobile application to help evacuate the underground installation

Miners do not have maps with themselves during their work. Maps are kept in Sztygarówka (supervisors place). Current safety regulations does not take new technology into account. Mines do not know where exactly their miners are. Personal safety equipment consists of oxygen masks enabling to survive 50 minutes, and lamps with GLON transmitter, allowing on detection from a few meters.

European Union encourages to search for a good solution for the miners localization, which, in one of the postulates of its set of recommendations for the coal and steel sector ('Personnel Tracking' task). There are solutions for underground localisation but they allows only to approximate miner's position (error can be range from 300 m (range of a single radio receiver) to the distance to the next transmitter).

This work is a response to the lack of a solution to aid the evacuation of a miner from a threatened area. As part of the work, presentations will be made of the positioning of underground systems, and a method of positioning in underground systems will be proposed, supported by measurements made during the test of the solution. Test will focus on stability, repeatability, accuracy and reliability factors. The work will discuss the mining model representation in terms of the location of the reference points, the location of the miner (system user), the safety points and the evacuation exits. The model should allow both the user to navigate to the nearest safety point, taking into account the current state of the corridors, and to allow presentation of the current position in graphical form. As part of the work, a complete model of the solution will be proposed along with the prototype of application for the mobile device. Finally, there will proposed future works that would base on a concept of integration of the location system with the function of remotely updating corridors. There will be provided example use cases.

Use case studies: fire, smoky corridor Use case studies: no electricity (dark, no ventilation)

Chapter 3

Hardware and enviornmental constraints

State of the art in underground navigation solutions. Theoretical topic.

*TO be adapted; book-wcin Requirements stated for communication system for the undeground operations: * must be intrinsically safe and explosion proof * should adhere to the ingress protection (IP) standards; * must be rugged in structure * must be size flexible * must have totality in design including cables, power supply unit, base stations, etc * must be value-added priced;e stations, etc * must be robust, inexpensive, easy to expand, and enable fast and secure connections

3.1. Phisics related to waves propagation in underground corridor

* Waves difraction, <tłumienie> * What are known issues related to wireless communication in underground installations

3.2. Udergground navigation - literature preview

* List of known positioning system in underground installations * Characteristics of known positioning systems ** Their concept Advantages and disadvantages ** How can be used ** How they perform the communication (physic/hardware aspect)

There are known solutions for location and monitoring people in undergorund installations. They are together named as LAMPS systems - Location and Moinitoring for Personal Safety systems. Those systems use three components in general: *

3.3. Mobile device sensorics - literature preview

* Why mobile device is good for positioning purposes? What are the factors? * What sensorics are present in mobile device. * Which of them will be useful to increase positioning accuracy

3.4. Abilities and limitations of mobile device in context of available positioning methods

* What means of communication (ex. wireless) can be used in context of positioning system * Battery limitations * Sensitivity of receivers

Chapter 4

Position finding basing on localization system and mobile device model

* What features should have the model in order to be used for navigation?

4.1. Solution requirements

Requirements as * The position of the mobile device will be determined by the environment model

Define criteria that will be used to compare position finding solutions (existing or conceptual) * How to save a corridor model in computer memory * wireless communication * resistance to power outages and communications * Do I need the ability to change configuration of reference points (configuration of devices that perform role of reference points)? * What parameters can be read from the reference points (range, distance,?) * How long should the network work properly? * How to detect irregularities in reference points? * How to fix problems in reference points? * What problems may occur with points of reference? * If there are restrictions upon existing network topology (ex. in order to get access to servers located on surface) * Can the mobile device be usefull in case of lack of signal (GSM/WiFi/BLE)? * example: accuracy, durability, cost, maintability (energy, fault)

Underground position finding system must be compatible with mobile devices of smartphone class. Special mobile devices that were prepared to work in bad conditions like in coal or salt mines differs mainly with their housing in compare their non-commercial, personal-use equivalents. This assumption limits the range of available technologies that can be used in order to provide means of communication between mobile device and the enviornment.

Position finding system bases on idea of interaction between mobile device and the undeground envioronment. In case of the nessesity of extension that enviornment by electionic devices that will provide positioning data or means of connection with mine network there is need to state that such devices must be safe. Safety regulations in this matter differs with respect of the type of underground installation, the regional, country, or even association of countries [7]. The goal of this paper is not to provide solution that will be adjusted to each installation type or safety regulation, but to investigate possibilities and propose state of the art solution. As the enviornmental restrictions for devices and related infrastructure that can be needed for given solution there will be assumed general rules that are being in use in commercial tunneling [7].

4.2. Known solutions analysis (against defined criteria)

* Advantages and disadvantages of solutions * How the solutions fulfil given criteria (ex. how accurate given solution can be)

Possible subsections that will discuss in detail given technologies. * communication technology: ** Bluetooth - the availability, supported by modern mobile technology, ** ZigBee, ** WiFi ** RFID ** ... others * system architecture ** server - client ** client - server ** WSN and IOT ** Peer-to-Peer [Felix C. P. Hui, Henry C. B. Chan, and S. H. Fung. RFID-based Location Tracking System Using a Peer-to-Peer Network Architecture[J]. Lecture Notes in Engineering Computer Science, 2014,2209(1):135-140.] ** With respect of where environment layout model is stored (related - GIS systems; GeoSoft, Vulcan, MineSight, SURPAC Range, or Mining Visualization System (MVS))

RFID technology make use of electromagnetic field phenomena that allows to transfer information to reader from special component, RFID tag. RFID tags are powered by readers though electromagnetic field; they do not use batteries or wired external supply. In order to acquire information from tag readers have to propagate electromagnetic waves. Tags cumulates power from electromagnetic field in capacitor. When tag have enough power then it transmits the response with tag's data to the reader and goes to sleep for a given time. Reader get signal from tag and perform filtering and decoding operations on it in order to get tag's data.

There are proposals of position finiding and tracking systems based internet of things (IOT) soultions [4, 10]. The idea is to create means of wireless communication to locate miners during their daily basis. It is proposed to create a network of wireless nodes (WSN) that read signal from tag devices (RFID) carried by miners and transfer it through nodes network to sink nodes that are directly connected to the mine core data transfer installation such as industrial Ethernet. Miners position data is sent to acquisition server. Intermediate and nodes are directly connected one or more nodes laying in the range of their wireless communication module. They form together ad hoc, multi-hop, self-organizing network of nodes that is able to transfer data, reorganise its structure in case of mailfunction of one of the nodes and allow to configure nodes remotely due to the implemented wireless communication technology and dedicated routing protocol. Network of nodes can be easily expanded by adding new nodes. Due to the fact that communication is wireless, nodes can be placed also in danger or new areas where wired network devices are not allowed or the related infrastructure doesn't exists.

WSN and RFID based positioning system is designed to serve such functionalities as querying miner information, locating miner, tracking miner and managing tag and reader. It is proposed to use this system along with simillary implemented monitoring system that measure safety parameters in mine [10]. This positioning system is dedicated to used by production monitoring, production scheduling and emergency rescue mine departments located on surface. Bigger precision can achived by adding more nodes into the network. Technology that is used for wireless communication between WSN nodes can be a Bluetooth Low Energy, ZigBee (IEEE 802.15.4 based) or WiFi

(IEEE 802.11). ZigBee technology is the most popular in WSN's as it supports variety of communication modes, contain out-of-box solutions for network topology management and support low energy solutions like sleep modes [2]. ZigBee protocol which is dedicated for ZigBee technology uses energy and computational efficient solutions for data collision avoidance which includes CSMA/CA techniques and time division concept [10, 9]. There are three main topologies forced by ZigBee technology that can be used in the WSN network: star topology, tree topology and mesh topology. Star topology limits the network to have all nodes directly connected to sink. Tree topology enables multihop functionalities but litmits network flexibility in therms of adopting routes in case of filure (doesn't support redundant connections between nodes). Mesh topology requires to store routing tables in each node but provides means of redundancy in therms of routing what makes the WSN network reliable and fault resistant [9]. The WSN positioning network proposal base on ZigBee technology and it's mesh topology. Placement of WSN nodes should guarantee signal coverage of RFID readers modules build into nodes. On order to achive that there are proposed variety of topologies that can be used on site during network installation. On image 4.1 it is presented the network topology proposal that introduces intermediate nodes – routing nodes – that gather information from sensor nodes and transfer it through network of routing nodes to server via sink node [10]. Due to the fact that WSN nodes are limited in energy supply, systems that base on that technology needs to be designed with aware of energy management and fault management. Idea of routing nodes deployment along the tunnel in two simmetrical lines comes from the need of link redundancy between nodes. Thanks to that even if some of routing nodes are down the information from sensors can be passed out through the other routing nodes that are in range. In order to limit power consumtion of reader nodes they were designed as Reduced Function Devices (RFD). These nodes do not take a part within information passing process. Reader nodes are designed only in purpose of reading signals from RFID tags and to send the information to the nearest routing node. In order to achive that the information will be sent only to the nearest reouting node there is performed initial configuration process that involve both reader nodes and route nodes in its signal propagation range. The process is such: reader node send the testing signal to all of the nodes. Nodes that were able to reiceve the signal, send responce with value of Received Signal Strength Indication (RSSI). Reader node limit its sending power according to the responces. Thanks to it power consumtion of reader node and interference with neighboring nodes are reduced.

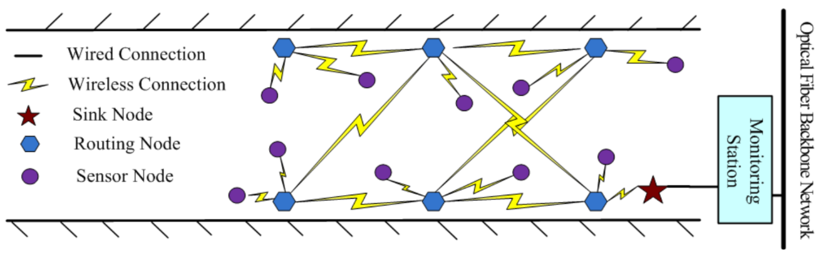

Figure 4.1. Wireless Network Sensor topology in corridor example [10].

Network of wireless connected nodes needs be designed with respect of its maintability. There is need to assume that some nodes may fail during their operation. As the network consits of many nodes, where the number of nodes can be changed during thier operation, there is need to implement actions that will allow them to organize their topology automatically. Even if particural nodes will fail, the rest of nodes should be able to work and maintain communication with remote services. It is the role of implemented routing protocol. There are available solutions that allow network to adapt quickly to the changing environment [3], but in case of statically placed network elements the environment is not changing havily. As it is in common practise, routing nodes stores information about nodes that are used for network purposes in the routing tables. Rounting tables are created with the manner that there are promoted link to nodes that ensure the lowest cost (distance) of packet travel from given node to the sink node. Routing table can have many entries. In case of topology for underground installation there are suggested 3 entries: parent route, minimum route, backup route [10]. Parent route points to the parent node, minimum route points to the best node in therms of the most energy efficient way to the sink node and backup node that points to the second to the best routing node. Each entry consists of elements such as: number of hops (routing nodes from itself to the sink node), value expressing quality of link of the last communication, flag that describe the role of the entry (parent, minimum, backup route). Routing tables and interconnections between nodes are created during network installation process. The idea is that the sink node that is directly connected to external communication medium creates at first 1-node WSN. Rest of nodes organize themselves in manner that nodes broadcasts their physical and network adresses. Basing on information gathered during installation they are able to determine their position in the network, obtain network address, assign routing table entries and obtain hop number. The network topology can be build up and maintain after WSN installation process [2]. Nodes are able to pass information to sink node that contains it's routing tables. Thanks to that sink node is able to recreate network topology and then pass the information to the external server. In order to maintain the network there are implemented status messages that contain information about changes in nodes routing tables. They are usually pass through WSN along with data from periodic sensor readings.

Nodes are equiped with batteries that makes them independent from external power source. In order to save the energy and in order to prolong device live on the battery nodes works in energy efficient modes. In these modes nodes are turned into sleep for certain time. They woke up in order to perform tag readings and transfer the data to the external resources. In order to synchronize their operation, in each cycle the sink node broadcasts the initial message which is used to synchronize all of attached nodes. Power level of nodes batteries are monitored. Nodes can send information about their power level as a repsponce for appropriate request. There can be implemented special routines inside node that can cause sending the information about the low battery level in emergency mode, without any request from the sink node.

The crucial for the positioning system is to determine accurately exact position of given reader node inside the underground installations. Without information about readers placement positioning data obtained from them are not usefull. Solution for this problem in WSN positioning systems are solved by manual configuration. Each node have it's own identification number that is a part of it's initial configuration. This number is atteched into their housing also so given nodes can be identified directly during the installation or maintenance work in tunnel. As nodes deployment is regular it is assument in advance what will be the position of the node within the tunnel. In case of sudden failure of some node it is possible to determinate which of the node is broken by it's ID information, and check were the node is placed. WSN network should have possibility to report failure of its nodes. That is why WSN positioning systems are equiped with failure detection and reporting mechanism. Parent nodes like routing nodes against reader nodes, checks if child nodes responds to the requests. In case of having no response from given node for a given amount of subsequent requests then parent node issue status request command to the child node and wait given amount of time. If child node give an answer then it is assumed that the given child node is working correctly. In case of no response from child node, the parent node send information about failure to external service. As the readers nodes are connected stright to the parent node with no routing options then different policy for borken parent node must be applied. If the child node does not reiceve acknowledgement (ACK) frame from it's parent given amount of times then the node increase it's sending power and retrainsmits it's data again. If there is no result of increasing the power then node goes into network setup mode and scan channel to rejoin the network.

Positioning algorithm in WSN positioning system base on mine layout and assume fixed position of nodes. Information about mine layout and nodes position wihin mine is stored in database on server above ground. Data transferred from nodes into acquisition server is a combination of three values: ID of a node, ID of acquried RFID tag in range of RFID reader module of that node, signal power of this RFID tag, and timestamp. Data is being stored in simplified relational database. This positioning system uses algorithm for finding exact position of RFID tag in dwo diamensional space (x, y). In order to do that algorithm search in database for 3 nodes that acquired given tag sinal with the biggest power. Then it uses simple free space electromagnetic waves propagation model (4.1) to compute distance between node and tag.

$$P_{ri} = \frac{P_t \cdot G_t \cdot G_{ri} \cdot \lambda^2}{4\pi D_i^2} \tag{4.1}$$

Parameters P_t (signal power generated by tag), G_t (tag antenna gain), G_{ri} (node reader antenna gain) and λ (electromagnetic wave length) are constant and known. Parameter P_{ri} (received signal power on reader's input) is the only variable in the equation that is needed to compute distance from tag to reader. Maximum likelihood estimation method that base on data from three nodes and thier values of reiceved signal power from given tag produces relative position of given tag in (x, y) coordinates. Suggested implementation [4] assume that nodes look for RFID nodes each 10 minutes.

4.3. Localization system choise (system based on beacons)

* Motivation * Prototype system description * Mobile device - system interaction description ** Method of detecting reference points description ** What are the possibilities to improve positioning on your mobile device? ** How could the process of installing a localisation system in a mine look like? ** How the parameters of the environment (corridor height, corridor width, type of rock, type of corridor corridors,

presence of other networks operating on similar frequencies (WiFi, GSM (harmonic frequencies)), others) affect reference point signal quality.

Chapter 5

Mobile device position finding algorithm

* Algorithm that will make use of chosen localization system and mobile device internal sensors.

5.1. Position finding requirements

* Should repeat and answer requirements stated for localization system. * example: ** Reading signal and its parameters from reference points; ** Identification of reference points ** Current location presentation on the environment model

5.2. Simple position finding algorithm implementation

* Simple algorithm will use localization system only (no internal sensors)

5.3. Extended position finding algorithm implementation

* Algorithm will use localization system and internal sensors

Chapter 6

Localization system tests

6.1. Tests criteria and assumptions

* Define factors that are important to state if solution is good or not * Will allow to check if system fulfills requirements * Test features stated in 'Localization system choise section'

6.2. Tests metodology

* Testing environment descipription * Equimpent used during tests. Example: ** using a representative wifi router, 801.11g techonology, simple circular antenna (eg Minetronics MMG) - for charts. ** using a representative beacon ** dBm signal strength depending on the distance and polarity of the mobile device from the signal source * Pictures

6.3. Tests of system and basic algorithm

* Check if system works with basic algorithm * Tests in few configurations * State if some factors have impact on signal quality * State if some factors have impact on position finding

6.4. Tests of extended algorithm

* Capture data that will be base for comparison between simple and extended position finding algorithm accuracy

6.5. Experiments results

* Resluts with analysis

6.6. Tests summary

Chapter 7

Conclusions

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