IoT TECHNOLOGY AND SUPPLY CHAIN MANAGEMENT

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Abstract

Purpose *- This article presents the supply chain management applications in economics but especially in the transportation industry.*

Methodology / approach *- The methodology proposed in this article is based on the use of ledger technology for the integration of transport sensor systems. Ledger technology integration methods are applied, and their results contribute to measuring performance in traffic management.*

Findings *- Based on the development of the processes realized by the authors, a methodology - was developed within the Department of Intelligent Transport Systems of UPB, for the integration of sensors from ITS.*

Research limitations / implications *- The paper offers a concrete solution obtained at the department level. This solution based on the implementation of the ledger technology algorithm represents a new approach for monitoring and transport planning in accordance with ITS requirements.*

Practical implications *- The practical aspects approached by the authors are related to the identification of the obstacles encountered in the implementation of urban transport planning management using ledger technology.*

Originality / value *- Methodology based on the supply chain management algorithms approach for monitoring and predicting traffic planning using IoT networks in ITS.*

Key words: *supply chain management, IoT, ledger technology.*

Introduction

The Internet of Things (IoT) initially established itself as a generous concept of direct (human) interconnection, via the Internet, of a multitude of devices, tools, equipment - eg household appliances, mobile vehicle systems ("Connected cars") that communicate with each other but also with the fixed infrastructure, (Barbu and all, 2015). In the the Romanian translation, by extension, "Internet of Objects" can include not only objects hardware (hardware) but also software objects (including in the sense of object-oriented programming) and, also, virtual objects - even going as far as "avatars" of things – models behavioral that are (transactional) representatives of physical objects, etc. Embedded with electronic components. By connecting IoT sensors to the Internet of the future through ledger technology, they can be monitored and controlled remotely in complete safety because ledger technology ensures data security through its particularity, namely the division of data segments into chained blocks. The structure and implementation of the Internet of Things (IoT) has evolved due to the development of new technologies, thus allowing the realization of integrated sensor systems, real-time monitoring and last but not least the implementation of the concept of supervised Machine Learning.

In the industrial field, the Internet of Things architecture is based on sensors, instruments and other electronic devices connected to industrial software applications (SCADA), including electricity production and transmission systems (Ziegler S, 2017).

This connection structure allows the acquisition, bidirectional data exchange and real-time data analysis, aiming at improving the parameters of productivity and efficiency in obtaining a superior management. The IoT concept has been criticized in particular for its privacy and data security issues. In recent years, IoT architecture has begun to be used in many directions of development, the most relevant being the concepts of Smart Home, Smart City and Smart Country (Ziegler S, 2015).

The main vulnerability in IoT is that access to software applications and sensors are brought together in a unified architecture. In this sense, ensuring an optimized and secure solution for users, regardless of the device with which they connect in the system, is a major goal for designers. For example, a user could access an online recipe through the screen of a smart home appliance and then transmit the information obtained to another user who is in traffic, to make purchases on the way home (Singh S, 2015). Currently, for IoT, a new concept called environmental intelligence and autonomous control appears, a concept that was not part of the incipient architecture of IoT. Due to the emergence of these new IoT concepts, correlated with the development of ledger technology (the first applicability being blockchain networks for cryptocurrency generation), there was a change in research (conducted by companies like Intel) to integrate IoT concepts, automatic control and ledger technology, taking considering that sensors become the engine of an autonomous ledger Internet (Narang S, 2018).

In this context, a new approach to machine learning appears, namely the use of Deep Learning neural networks, which will allow sensors in IoT networks to learn on their own, thus providing a dynamic development environment.

Blockchain technology and the Supply Chain Management

In this article we will analyze how one of the most prominent existing technologies - ledger technology (blockchain), can change the transport industry.

While the most widely used application of this technology is in cryptocurrencies, such as Bitcoin and Ethereum, the applications of ledger technology go beyond this use.

Blockchain, is a digital register of transactions; which contains a widely distributed database and stores all historical data in chronological order (traceability). The data is stored in blocks and can be viewed by all network users, without being able to make changes.

As an architecture, the Blockchain network must meet the following basic requirements: security, accessibility, traceability and transparency - and the blockchain is built to bring all these benefits and add something extra to industrial developments. The advantages for the transport industry (road, naval, air) are the following: it reduces bureaucracy (documentation), reduces costs and human administration of the process, facilitates the establishment and planning of routes and automates the tasks of drivers.

Blockchain can also be used to simplify the supply chain, reducing human interaction, increasing the speed of supply management and allowing communication between vehicles.

Starting from document management and transport tracking, ledger technology can act as a communications network for the Internet of Things (IoT) and will facilitate the use of radio frequency identification (RFID), rapid response codes (QR) and tags, blocks will allow storage large amounts of data, in a secure and decentralized way, ensuring fast data processing in a short time. Security is another important feature of blockchain technology. Currently, cryptocurrency trading information is stored in blocks that cannot be modified and immutable, which means that it is impossible to change it without the consent of the smart contract partner, because the calculations needed to make informational changes in blocks require a lot of processing power. great because they are stored centrally.

In addition, even if certain users want to make changes, they become visible to all members of the network, because the blocks but also the transaction history can be viewed by the participants in the transactions. The combination of ledger technology (Blockchain) and the IoT network can be achieved on three levels: IoT devices, Edge nodes and Cloud servers. The control and intelligent decision of the IoT network depends on the performance of software applications that use artificial intelligence algorithms. For example, the autonomous vehicle camera must detect obstacles in real time to avoid an accident. Smart decision making cannot be done without transferring data from the vehicle to the Cloud servers / nodes and resending the resulting predictions back to the vehicle. Instead, the entire operation must be performed locally in the vehicle. The integration of advanced machine learning algorithms, especially deep learning in IoT devices, is a research direction in order to bring smart sensors as close as possible to the reality of human thinking.

In addition, an innovative element in the structure of IoT networks will be their ability to extract information and predict / anticipate events, so that the human factor can make control decisions in a short time (Jara J, 2014) .

Internet of multimedia objects (IoMT) and Ledger Tehnology

Currently, due to the demand-driven economy, the supply chain model has had to undergo transformations. At this point, the supply chain is not just a chain, and the supply management system has evolved through an IoT interconnection with a multitude of websites that can be accessed permanently.

"Internet of Things" Multimedia (IoMT) is a new development direction in which different sensors of intelligent multimedia type and can interact and collaborate with each other, but can exchange information and other devices within IoT networks, so they can quickly exchange information multimedia from around the world. Based on this concept, IoMT networks are integrated worldwide. Today, over 9 billion multimedia network devices are connected to the Internet, contributing to the development and management of communication services (e-mail, social networks, chat, blog), forums, entertainment activities (games, books), shopping, exchange knowledge (education, geographic information, encyclopedias) for over 2.5 billion people worldwide (Frustaci M, 2017). In an IoT-based multimedia system, intelligence and decision-making are embedded in sensors. Similarly, a Cloud server has the ability to develop, maintain and execute various services, providing large scalable computing and data storage resources, using Artificial Intelligence algorithms. This approach allows users to monitor and control devices in any corner of the world. However, the currently existing Cloud services (ThingSpeak, Xively, ioBridge, Carriots, Axeda) are limited to managing the user's device and recording data from sensors. Existing Cloud servers have been implemented only for the processing of data received from IoT, which transmit information asynchronously and at long intervals (Iglesias M, 2017). The role of IoMT networks is defined by two user services as follows: wireless multimedia systems, which are used to monitor the quality of the environment, and detection sensors can receive feedback based on applications that use intelligent agents; procurement process control systems; and Wireless networks for multimedia sensors (WMSN), but these devices have a limited ability to receive feedback. In traditional multimedia networks, multimedia devices only transmit multimedia information purchased near them. Multimedia content can be transmitted to the user or stored on Cloud servers for further data processing at the request of users. In general, the architecture of multimedia devices is designed for communication with other multimedia devices with similar technical characteristics (homogeneity), in the future it will be possible to integrate inhomogeneous devices.

Today, IoMT communication allows multimedia devices, such as cameras or mobile phones, to be accessed globally via a single IP address, as can connectors or other devices connected to the Internet. Due to the technological progress of miniaturizing the size and costs of multimedia devices, connected in IoMT networks will be widely used, and these devices will be able to create ad-hoc connections with all devices in the network using ledger technology. Thus, IoMT networks with communication on ledger technology will become globally interconnected networks, which will be uniquely identifiable and addressable to obtain multimedia data or to predict the development of actions, having the ability to communicate and exchange information with other devices. and multimedia services, with or without human intervention. In this new configuration, the traffic monitoring systems will move to a new level, and based on deep learning software applications for object detection and recognition, they will be able to predict traffic flows, transmitting to the network the traffic flow control commands and travel.

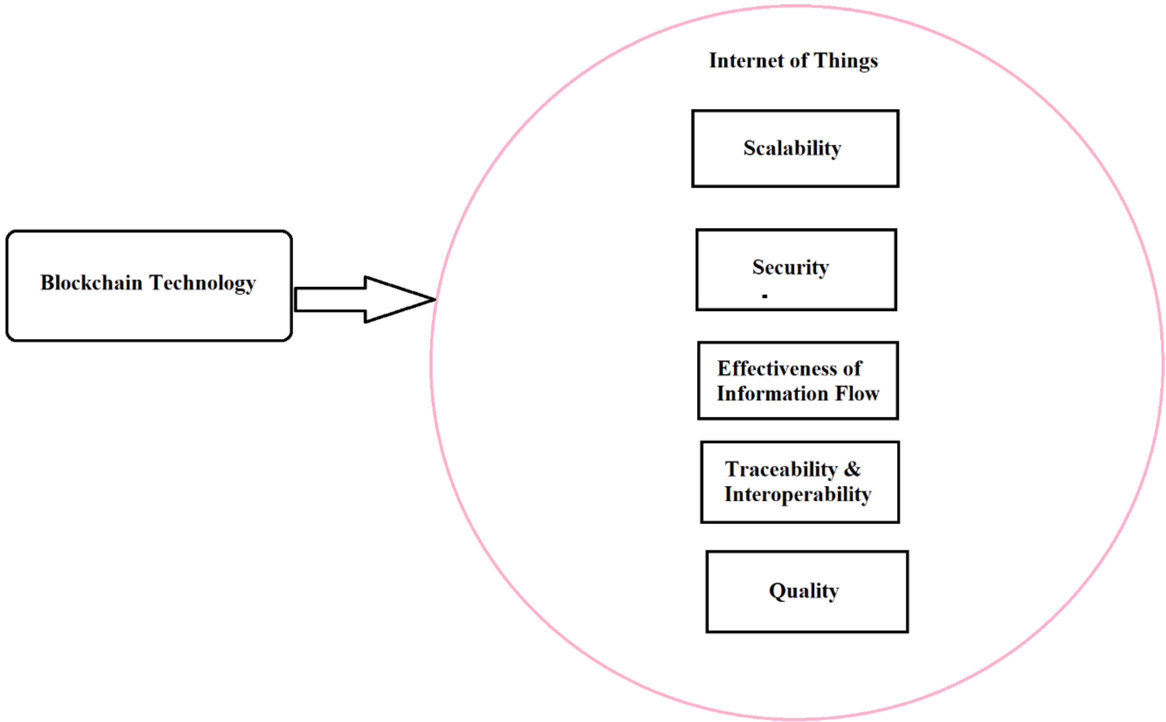

Figure 1. IoT interconnection with Blockchain technology

Large amounts of multimedia data (Big Data) are subjected to different data processing procedures in order to reduce the volume of data to be transmitted on the multimedia device - transformation, quantification, estimation, entropy encoding, vectorization, so that the data content can be tablet to comply with the available bandwidth during transmission. This problem will be solved by implementing 5G mobile communications worldwide. The previously mentioned processing processes are complex in terms of computing resources, consuming a large amount of energy. Currently, various solutions are being tested for streamlining multimedia communications, including compressive detection, distributed video encoding based on blockchain technology, which will be used to facilitate the acquisition and processing of multimedia devices on IoMT networks.

Based on the functional requirements of IoMT networks, video encoding techniques can be classified into three categories:

- Conventional video encoding
- Distributed video encoding
- Acquisition with statistical compression rate (“compressive sensing / compressive sampling”)

Challenges in IoMT development. The transmission of multimedia content from the sensor to the Cloud server with processing and storage applications, can generate traffic management restrictions, which are essential for real-time transmission of continuous video streams, which can introduce acquisition delays or breakages, aspects that for a video traffic monitoring system in ITS networks can cause major inconveniences. These inconveniences can cause a malfunction of software applications developed with Artificial Intelligence algorithms for object detection and recognition (cars, pedestrians, face detection and recognition, tracking a car). For example, users may be allowed to ubiquitously access data from remote sensors and sets of rules may be implemented to control the automatic operation of actuators in the Cloud ("sensor and actuation as a service" - Sensing and Actuation as a Service , SAaaS), to control Identity and Policy Management as a Service (IPMaaS), allowing processing to real-time analysis for video surveillance streaming (VSaaS) and so on The desired goal is to reduce human involvement in IoMT to a viable minimum - including in detecting objects and movements, facial recognition, identification of license plates, situational and acoustic awareness, forensic analysis, detection of theft or prohibited access, etc. In conclusion, some new possible uses of IoMT are:

telemedicine, intelligent social interaction, intelligent business management (eBusiness), automatic public security.

Research Methodology: IoT integration in the Cloud through real-time web ledger technology communications (Web-RTC)

WebRTC (short for Web Real-Time Communications) is a collection of communication protocols and application programming interfaces (APIs) that allow real-time communication (with a latency that has fallen far below the time constants of human perception; or of industrial processes) using peer-to-peer (P2P) connections (Mardan A, 2014). This allows web browsers to send and receive information in real time, from and to other users' browsers - the premise for this is the new speed and capacity performance of IP communications.

Traditional web models are developed on the client-server architecture in which the communication is performed unidirectional (from server to client). The WebRTC architecture develops the client-server model by incorporating the notion of P2P communication ("peer-to-peer") between web browsers (Kelleher J, 2016). The most widely used WebRTC architecture is the triangular model in which the two web browsers access an application on a server (located "at the top of the triangle") - through this application, signaling messages are transmitted via HTTP protocol or Ledger technologies (Wen Y, 2010). Validation and consensus for Ledger technology was achieved by Proof-of-Work.The blockchain using a procedure Proof-of-Work (PoW) to validate transactions and create new blocks. The original purpose of PoW was achieved as an economical measure to discourage distributed service (DDoS) attacks and the generation of spam in the network. This function is performed by requesting "validations" by the service provider. For example, on the blockchain "validation" consists in calculating a double hash function of type SHA256. Usually all blockchain networks are based on validation and a certain consensus (Peters & Panayi, 2016).

```
% Copyright 2019 The DCM&MathWorks, Inc
classdef Blockchain < handle

    properties
        blockchain
    end

    methods
        function obj = Blockchain()
            obj.blockchain = bc.Blockchain.genesis_block();
        end

        function block = add_block(obj, data, nonce)
            assert(isa(nonce, 'uint32'));
            index = numel(obj.blockchain) + 1;
            prev_hash = obj.blockchain(end).hash;
            timestamp = char(datetime);
            hash = bc.Blockchain.calculate_hash(index, prev_hash,
timestamp, nonce, data);
            block = bc.Block(index, prev_hash, timestamp, data, nonce,
hash);
            obj.blockchain(end+1) = block;
        end

        function added = add_mined_block(obj, block)
            assert(isa(block, 'bc.Block'));

            valid = bc.Blockchain.validate_block(block,
obj.blockchain(end));
```

```
            if valid
                obj.blockchain(end+1) = block;
                added = true;
            else
                added = false;
            end
        end

        function rv = replace_blockchain(obj, new_blockchain)
            valid = bc.Blockchain.validate_chain(new_blockchain);
            if ~valid
                rv = p2p.MessageType.DO_NOTHING;
                return;
            end
            if numel(new_blockchain) > numel(obj.blockchain)
                obj.blockchain = new_blockchain;
                rv = p2p.MessageType.BROADCAST_LATEST;
            end
        end

        function print(obj)
            fprintf('\n==================================\n');
            for idx=1:numel(obj.blockchain)
                fprintf('index: %d\n', obj.blockchain(idx).index);
                fprintf('timestamp: %s\n', obj.blockchain(idx).timestamp);
                fprintf('data: %s\n', obj.blockchain(idx).data);
                fprintf('nonce: %d\n', obj.blockchain(idx).nonce);
                fprintf('hash: %s\n', obj.blockchain(idx).hash);
                fprintf('previous_hash: %s\n\n',
obj.blockchain(idx).previous_hash);
            end
            fprintf('==================================\n\n');
        end

        function rv = handle_blockchain_response(obj, mess)
            % Convert incoming message of strcut or array of struct
            % to array of blocks
            received_blockchain = bc.Block(mess(1));
            if numel(mess) > 1
                for idx = 2:numel(mess)
                    received_blockchain(end+1) = bc.Block(mess(idx));
                end
            end

            latest_block_received = received_blockchain(end);
            latest_block_held = obj.blockchain(end);
            rv = p2p.MessageType.DO_NOTHING;

            % If received latest block is not later than the local, do
            % nothing.
            if latest_block_received.index > latest_block_held.index
                if latest_block_held.hash ==
latest_block_received.previous_hash
                    % We can append the received block to our chain
                    % FIXME validate block
                    valid =
bc.Blockchain.validate_block(latest_block_received, latest_block_held);
                    if valid
                        obj.blockchain(end+1) = latest_block_received;
                        rv = p2p.MessageType.BROADCAST_LATEST;
```

```
                end
            elseif numel(received_blockchain) == 1
                % We have to query the chain from our peer
                rv = p2p.MessageType.QUERY_ALL;
            else
                % Received blockchain is longer than current blockchain
                rv = obj.replace_blockchain(received_blockchain);
            end
            % Above only works if only one block or entire chain is
            % sent, which should be the case.
        end
    end
end

methods (Static = true)

    function gen = genesis_block()
        % FIXME mine the block for correct hash
        % Create genesis block
        index = 1; % Yes it is MATLAB
        prev_hash = char(0);
        timestamp = '07-Dec-2017 01:19:33';
        data = 'The origin';
        nonce = uint32(0);
        hash = char(uint8([159 253 165 212 162 203 121 5 144 7 7 212 3
29 209 119 128 39 5 152 71 69 214 107 142 245 155 146 123 159 164 236]));
        gen = bc.Block(index, prev_hash, timestamp, data, nonce, hash);
    end

    function valid = check_if_genesis(block)
        assert(isa(block, 'bc.Block'));
        gen_str = ['1', char(0), '07-Dec-2017 01:19:33The origin0',
char(uint8([159 253 165 212 162 203 121 5 144 7 7 212 3 29 209 119 128 39 5
152 71 69 214 107 142 245 155 146 123 159 164 236]))];
        blk_str = [num2str(block.index), block.previous_hash,
block.timestamp, block.data, num2str(block.nonce) , block.hash];
        if strcmp(gen_str, blk_str)
            valid = true;
            return;
        end
        valid = false;
    end

    function [sha256, uint8_sha256] = calculate_hash(index, prev_hash,
timestamp, nonce, data)
        string = [num2str(index), prev_hash, timestamp, num2str(nonce),
data];
        sha256hasher = System.Security.Cryptography.SHA256Managed;
        uint8_sha256 = uint8(sha256hasher.ComputeHash(uint8(string)));
        sha256 = char(uint8_sha256); %consider the string as 8-bit
characters
    end

    function valid = validate_chain(blockchain)
        valid_genesis = bc.Blockchain.check_if_genesis(blockchain(1));
        if ~valid_genesis
           valid = false;
           return;
        end
```

```
            temp_blockchain = blockchain(1);

            for idx=2:numel(blockchain)
                valid_blk = bc.Blockchain.validate_block(blockchain(idx),
temp_blockchain(idx-1));
                if valid_blk
                    temp_blockchain(end+1) = blockchain(idx);
                else
                    valid = false;
                    return;
                end
            end
            valid = true;
        end

        function valid = validate_block(new_block, prev_block)
            assert(isa(new_block, 'bc.Block'));
            assert(isa(prev_block, 'bc.Block'));

            % FIXME check for correct hash (with 0s)
            if ~(new_block.hash(1:2) == char(zeros(1,2)))
                valid = false;
                return;
            end

            if (prev_block.index+1) ~= new_block.index
                valid = false;
                return;
            end

            if ~strcmp(prev_block.hash, new_block.previous_hash)
                valid = false;
                return;
            end

            new_block_hash = bc.Blockchain.calculate_hash(new_block.index,
...
                new_block.previous_hash, new_block.timestamp,
new_block.nonce, new_block.data);
            if ~strcmp(new_block.hash, new_block_hash)
                valid = false;
                return;
            end
            valid = true;
        end
    end
end
```

Figure 2. Proposed communication algorithm between IoMT and Ledger technology

Workflow approach on neural networks

LabVIEW and Matlab are software development environments for object recognition and classifications solution uses neural networks and Deep Learning algorithms (Wen Y, 2010).

LabVIEW workflow overview:

1. Object recognition and classifications using a trained model.
2. Cars and pedestrian data transformation for neural networks analysis.
3. Representation of the object on a 128-dimensional data using deep neural networks.

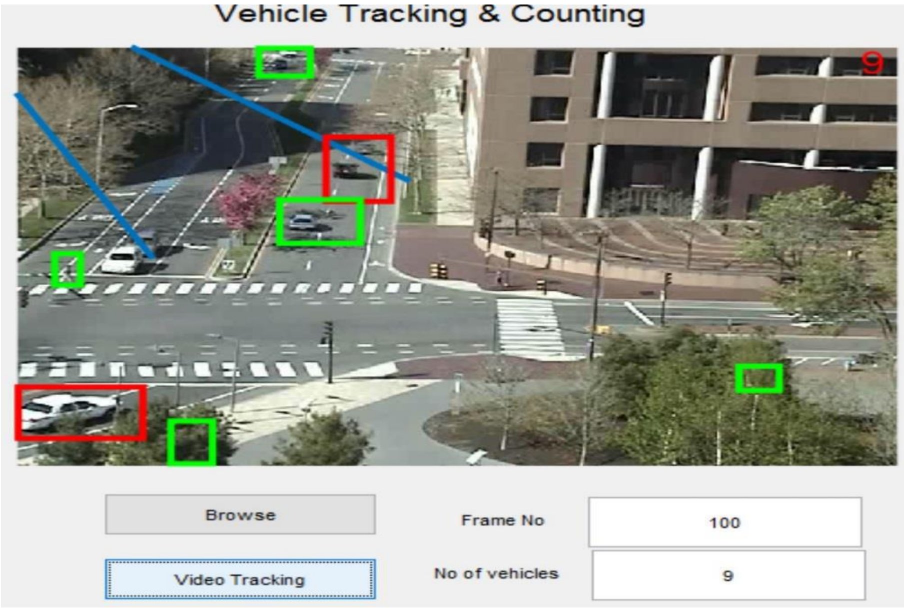

Figure 3. Cars and person recognition using Deep Learning Neuronal Networks

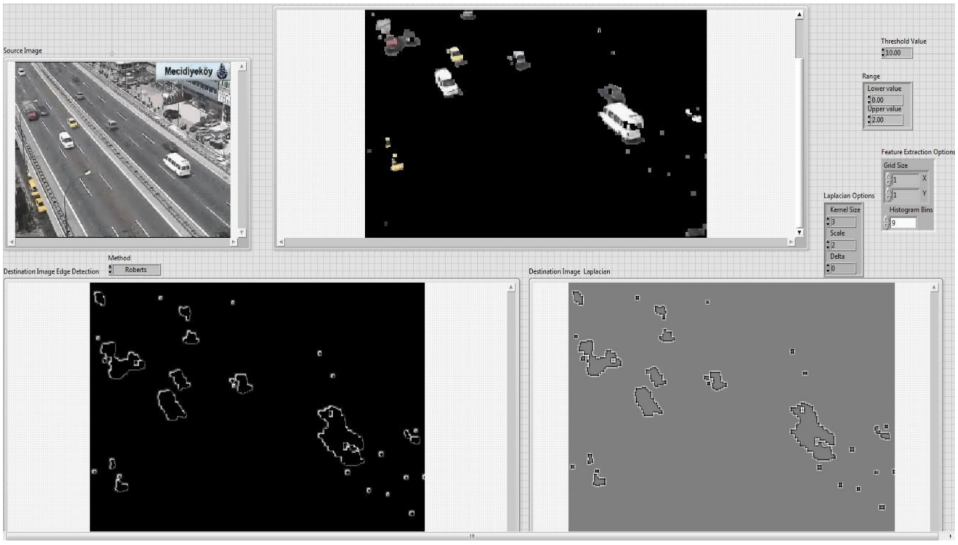

Figure 4. Vehicle motion detection from highway detection and analyze using IoMT

One of the main advantages of using LabVIEW in the development of software applications with neural networks is the possibility of importing extensive libraries of objects. The training database for object recognition and classification will be installed on Cloud servers and can be accessed and used in data processing and object recognition using software applications developed within the department.

Conclusions

The supply chain industry is the backbone of any country's economy. The modern supply chain ecosystem is quite complex, with many entities involved in the process, which leads to lower efficiency and higher operating costs. Currently we can see that the management of the supply chain used in the field of transport has developed significantly, starting from manual operations that generated prediction risks, reaching automatic management, in real time, which is not a risk generator. The use of IoT and blockchain technology (ledger) together with applications developed for supply chain management has a major impact on road, sea and air traffic management, in tracking goods and supply (efficient inventory management and reducing supply chain losses) . This has contributed to the achievement of economic benefits for companies and has helped to expand the supply chain over large geographical areas (eg Amazon). Starting with the use of simple goods identification devices and arriving at a complex architecture that works in an intelligent system, IoT has revolutionized the transportation and supply chain industry, starting with supply, product selection and delivery to users.

References

S. M. Babu, A. J. Lakshmi, and B. T. Rao.
2015.
"A study on cloud based Internet of Things: CloudIoT". In 2015 Global Conference on Communication Technologies (GCCT). 60–65. doi.org/10.1109/GCCT.2015.7342624

S. Ziegler,
2017
"Considerations on IPv6 scalability for the Internet of Things — Towards an intergalactic Internet," 2017 Global Internet of Things Summit (GIoTS), Geneva, 2017, pp. 1-4. doi: 10.1109/GIOTS.2017.8016238

S. Ziegler, S. Nikoletsea, S. Krco, J. Rolim and J. Fernandes,
2015
"Internet of Things and crowd sourcing - a paradigm change for the research on the Internet of Things," 2015 IEEE 2nd World Forum on Internet of Things (WF-IoT), Milan, 2015, pp. 395-399. doi: 10.1109/WF-IoT.2015.7389087

S. Singh and N. Singh,
2015
"Internet of Things (IoT): Security challenges, business opportunities & reference architecture for E-commerce," 2015 International Conference on Green Computing and Internet of Things (ICGCIoT), Noida, 2015, pp. 1577-1581. doi: 10.1109/ICGCIoT.2015.7380718

S. Narang, T. Nalwa, T. Choudhury and N. Kashyap,
2018
"An efficient method for security measurement in internet of things," 2018 International Conference on Communication, Computing and Internet of Things (IC3IoT), Chennai, India, 2018, pp. 319-323. doi: 10.1109/IC3IoT.2018.8668159

A. J. Jara,
2014
"Wearable Internet: Powering Personal Devices with the Internet of Things Capabilities," 2014 International Conference on Identification, Information and Knowledge in the Internet of Things, Beijing, 2014, pp. 7-7. doi: 10.1109/IIKI.2014.9

M. FRUSTACI, P. PACE, G. ALOI, and G. FORTINO.
2017.
Evaluating critical security issues of the IoT world: Present and Future challenges. IEEE Internet of Things Journal PP, 99 (2017), 1–1. https://doi.org/10.1109/JIOT.2017.2767291

M. Iglesias-Urkia, A. Orive, M. Barcelo, A. Moran, J. Bilbao, and A. Urbieta.
2017.
Towards a lightweight protocol for Industry 4.0: An implementation based benchmark. In 2017 IEEE International Workshop of Electronics, Control, Measurement, Signals and their Application to Mechatronics (ECMSM). 1–6. https://doi.org/10.1109/ECMSM.2017. 7945894

Azat Mardan,
2014
Practical Node.js: Building Real-World Scalable Web Apps, Apress, 2014, ISBN: 978-1430265955;

John D. Kelleher, Brian Mac Namee,
2016
Fundamentals of Machine Learning for Predictive Data Analytics, MIT Press. 2016 - ISBN: 978-0262029445

Peters, G. W., & Panayi, E.
(2016).
Understanding modern banking ledgers through blockchain technologies: Future of transaction processing and smart contracts on the internet of money. In *Banking Beyond Banks and Money* (pp. 239-278). Springer, Cham.

Yi-Wen Luo,
2010
"The effect of using JavaScript and HTML to implement an E-learning web sites as a remedial teaching aid on English underachievers at universities of science and technology", Computers and Industrial Engineering (CIE) 2010 40th International Conference on, pp. 1-7, 25-28 July 2010.