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Exchange of Information and Knowledge in Research

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- to promote exchange of information and knowledge in research work and
- to explore the new developments and inventions related to the use of Information Technology towards the structuring of an Information Society.

JITA provides a medium for exchanging research results and achievements accomplished by the scientific community from academia and industry.

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Contents

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Dear Readers,

This issue of JITA contains four regular research papers. The first of the presented papers, entitled "Using 3D models for improving face recognition", by Zoran Bikicki, Ivan Milenković, and Dušan Starčević is dealing with PCA face recognition algorithm. PCA (Principal Component Analysis) has a significant performance drop when comparing photographs taken from the different angle. In this paper a 3D model was used for improving PCA performance in this case. Using captured face image as the texture, 3D model enables transformation of the two-dimensional face to the three-dimensional face model. Three-dimensional face model is then rotated in order to transform face images from profile to en face position. Model has been tested against collected biometric database. Study results show that PCA algorithm precision on biometric verification and identification has been seriously improved.

In the paper "E-textbook development capacities within the current context in the Republic of Serbia", by Željko Stanković and Ljiljana Tešmanović the problem of e-books and e-textbooks has been presented. In digital age and with the adoption of new technologies, new educational digital platform has become an integral part of our everyday life and education which requires adjustments and changes in the educational system structure. In order to make the students be equal and functional members of the society and to prepare them for contemporary digital era, it is the entire society's most important responsibility to enable educational system to provide, in most optimal and proficient way, equal opportunities for each and every student to gain knowledge. Expensive process of a book digitalization will, in time, become economically acceptable for all in the broader community.

In the paper "Hybrid methodology of nonlinear goal programming", Lazo Roljić presents a nonlinear goal-programming (NGP) algorithm based on hybrid connection of the modified simplex method of goal programming, gradient method of feasible directions and method of optimal displacement size finding-called HNGPM. Proposed methodology is given in five steps: (1) linearization of the set of nonlinear constraints at particular point, (2) solving the problem of normalized linear goal programming, (3) feasible direction computation, (4) calculating optimal step length displacement, and (5) testing out convergence problem. Basic idea was to apply Euler's theorem for the "total" linearization of the nonlinear constraints (in the space) around particular point. According to Euler's theorem, it is possible to apply this methodology to solve the problems of NGP whether the nonlinear constraint functions are linearly or positively homogeneous.

Finally, the last article "Aquaculture cloud management system" presents a specific approach to the management system for aqua-farms. The proposed management system is based on expert system paradigm implemented in cloud environment and makes use of the Internet of Things. The system employs RFID sensors to monitor the aqua-farms, allowing personnel to keep tabs on the facilities at any time. Such design facilitates 24 hour monitoring of facilities while reducing con-

sumption of resources. In the first design phase, the experts on aqua-farming are interviewed. Collected data were compiled and stored in the database. The inference engine was then used to store the data in the knowledge base, achieving the aim of knowledge management. Apart from helping aqua-farms conserve resources and improve quality, presented aquaculture cloud management system allows consumers to understand the production process and make informed purchasing decisions.

With this 8th issue, the Journal of Information Technology and Application (JITA) successfully completes the 4th year of publishing. A brief analysis indicates that in these eight issues, a total of 46 scientific papers have been published, that is around 6 papers per issue. By the type of published scientific contribution, 20 papers relate to the improvement of scientific methods in the area in question, 14 papers illustrate the results of research based on the case study, 8 papers contain a breakdown of condition in the part of scientific area, and 4 papers represent a critical review of well-known scientific procedures.

If we look at the analysis of published papers from the perspective of geographical distribution of institutions were the original authors of papers are employed, then we have data as follows: most of the published papers, 40 out of 46 belong to the region, which amounts to around 87% of the total number of papers. From the territory of Serbia, we had around 43% out of the total number of papers, where around 30% of papers come from the Republic of Srpska, and from the Federation of Bosnia and Herzegovina around 9% of the total number of papers. The participation of authors from Montenegro and Macedonia in the previous period was modest 2% of the total number of papers. Out of the remaining six published papers, according to geographical setting, three papers come from the North America (two from Canada and one from the USA), two from Europe (one from Italy and one from Portugal), and one paper from Asia (Taiwan). Based on the stated analysis, it can be concluded that, in this moment, the JITA holds a status of regional journal.

Ministry of Science and Technology of the Republic of Srpska, the Commission for categorization of scientific journals, at the meeting held on 11/06/2013, categorized the Journal of Information Technology and Application, published by the PanEuropean University Apeiron, Banja Luka, in the first category of scientific journals.

We invite all interested parties to send to the journal Editorial Board the results of their scientific and research work, about which, as they believe, the scientific community should be informed.

Using 3D Models for Improving Face Recognition

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Contribution to the state of the art

DOI: **10.7251/JIT1402055B** UDC: **004.6.056.55**

Abstract: Face recognition algorithm Principal Component Analysis (PCA) has a significant performance drop when comparing photographs taken from different angle. In this paper a 3D model was used for improving that performance. Model enables us to transform the face image which is taken from certain angle to en face. Model has been tested against biometric database formed at the Faculty of Organizational Sciences. Image rotation based on the model was performed before matching with the en face images from the database. Study results show that algorithm precision on biometric verification and identification has been seriously improved.

Keywords: biometrics, face recognition, 3D graphics, PCA

Introduction

Human face represents a specific characteristic of each human being. When interacting with other people, humans direct attention toward their face. Facial characteristics are used to recognize friends and family members from other, unknown people. Human brain is relatively successful in facial recognition, even under difficult conditions, such as bad lightning, face aging, use of spectacles or haircut change. Although this recognition may seem simple, it is not. It is performed by neural networks located in human brain, which process images collected with eyes, compare them with stored face images and make recognition decision.

Applying computers to this task does not make facial recognition less complex. For example, if we have a collection of photos of certain person, probably the first idea would be to compare pixels or photo histograms. These algorithms are successful when dealing with image search on the internet, or protecting copyrighted material. However, in access control or surveillance system, computer does not work with copies, but with photographs of live humans. They move around, change haircut, wear glasses, and change facial expressions, making recognition more difficult. A significant recognition problem is the fact that actual persons exist in tridimensional space, but they are usually represented by two-dimensional photos.

Automatic facial recognition with use of computers is still in development, with numerous challenges remaining to be solved. In laboratory conditions, without outside interferences, modern face recognition systems have good performances. However, problems such as change in lighting, camera angle and occlusion have a significant impact on biometrics system performance.

Because cameras became even cheaper and widely available, biometric systems for face detection and recognition have numerous applications in different areas. They are used for facial recognition in photographs on social networks, election fraud detection, access control systems and also surveillance systems.

This paper will examine the change of head position on a face image. This problem is especially important for face recognition algorithms which use 2D face images. For evaluation purposes, eigenface algorithm will be used. In order to improve the performance of the algorithm, it is necessary to "draw" the image in three dimensions. With such image we could change its position – turn it until the proper frontal position is reached. Use of frontal images should positively impact precision of eigenface algorithm.

To return face to the frontal position we will use a three-dimensional model of the face that we plotted by using the graphics card. Necessary requirement for successful mapping is to manually install the model in such a position in which certain characteristic points of the face and models coincide. These points will be the central point of the eyes, and the tip of the nose. In this way, we will be able to precisely determine the position of the face.

FACE RECOGNITION

Face recognition includes several different tasks:

- **Identification –** for a given photo, system tries to find matching person in the database, or to conclude that person on the photo does not have any biometric data in the database
- **Verification –** for each pair <image, person>, system has to verify if biometric data belongs to identified person identity, or not
- **Segmentation –** An array of images is grouped in accordance with persons' identities.

First recognition algorithms were based on facial features. As a general principle, all of these algorithms try to detect key face elements, like eyes, eyebrows, cheeks, nose and other. These data is used to calculate dimension of key face elements, view angle and distances between different parts of the face. Most algorithms use around 40 key elements, and performance of algorithms somewhat varied. Paper [4] describes such algorithm. However, landmark approach has not shown satisfying precision. The main reasons for poor performances are difficulties connected with correct identification of face elements, and neglect of information found in face textures.

The second group of algorithms which arose later, and which still hold primacy in this area are based on the observation of the face as a whole (appearance based). Algorithms from this category store face templates in biometric templates, and match templates as whole with acquired face data. There are numerous algorithms from this category, from which some are frequently used and very popular.

The first algorithm in this group is the so-called Eigenface algorithm [7]. This algorithm is based on the principal component analysis. Principal component analysis is a statistical method for the reduction of a number of variables that are observed in a small number of new variables called principal components. The idea is to find the characteristic vectors (eigenfaces) on the covariance matrix of a face image set, where we treat each image as a vector in a multidimensional space. Graphical representation of eigenfaces is shown in Fig.1. Template of each person in the database is stored as a vector, more precisely a linear combination of these characteristic vectors of the face. For comparing vectors obtained from different persons, we can use different methods, such as Euclidean or Mahalanobis distance.

FIGURE 1. GRAPHICAL REPRESENTATION OF EIGENFACES

Implementation of the eigenface algorithm is availabe within the OpenCV computer vision library. OpenCV is an open source library that contains functions for implementation of computer vision. It is written in the programming languages C and C++, and has support for Windows, Linux and Mac OS X operating systems. OpenCV was used for testing effect of proposed solution on system precision.

3D modelling

Three-dimensional modeling is a set of techniques that are used for creating, modifying and finishing three-dimensional models. Most famous professional tools are "3D studio max" or "Maya". These tools are very expensive, both costing nearly $ 6,000 for the basic version [10]. There is also some free software in this domain, such as "Blender". For the purposes of this paper, we have taken an open source model of the head and developed software for modeling, by removing all polygons that do not belong to the face. The result of the modelling is a three-dimensional model, and this work is mainly concerned with artists, architects or designers. In addition, models can be generated by using computers, which require some description and a set of functions.

There are many possible ways to memorize a three-dimensional model. File formats also vary, as models can be textual - that people can easily read, or binary - that is a collection of bytes that computers can easily load to memory.

An example of textual file format is the "obj" [9], in the positions of points are recorded as text. Lines beginning with # character are comment lines, which is common in text files. Symbol "g" marks the group, and "usemtl" describes what texture is to be used. This is followed by points in space ("v" from "vertex"), texture coordinates ("t" from "vertex texture"), normal ("n" from "vertex normal") and the surface ("f" from "face"). Surfaces are actually triangles that make up the three points in space and it is the most common way of marking the model. Normals are used for lighting, but they can also be omitted and after subsequently calculated. An example of this file can be seen in Table 1. The model can have one or more of these groups, which are called meshes. This file format is simple and readable, but the models remembered in this format take up more disk space and are slower to load into memory, because words need to be converted to numbers.

Table 1. An example of "obj" file

```
# WaveFront *.obj file (generated by CINEMA 4D)
g wheel_3
usemtl _06_kolonki__spec_
v -1.915311 -0.144131 3.745234
v -1.915311 -0.14204 3.640694
v -1.915311 -0.1164 3.639594
vt -22.3438 23.506798 0
vt -19.2136 23.569401 0
vt -19.180599 24.336998 0
f 1/1 2/2 3/3
```

A significant part of each three-dimensional model is the texture. Texture represents the image that is "glued" on certain parts of the model. It is possible to use multiple modes for setting up the textures. In one case, where the coordinates can take values from zero to one, the texture is used as the final image and it is not possible to get out of the frame of the textures. In the second case the texture is repeated, wherein the texture is an infinite plane. One model can use several textures.

Using 3D models for face recognition

As for using 3D models for face recognition there is the paper of Blanz and Vetter - they used a 3D laser scanner for acquiring a database of 200 persons [1]. Afterwards they manually defined points for eyes mouth and nose, and then recognition was being performed by interpolating 3D models from the database. Their research has shown good results.

Other papers are mostly based on face recognition using 3D camera. In this way good results are being given, but this approach calls for expensive equipment. Besides, this cannot be applied to 2D images, so it is not possible to work with existent databases. Some papers using this approach are [3] and [5].

Program description

A program was developed for transforming 2D images so that the face will be en face. It uses an input image as a texture for a head model, rotates the model and exports the rendering.

The program was written in programming language C++. The main reason for selecting that programming language is performance and ability for

direct memory access. The 3D graphics library used was OpenGL, which enables graphics hardware acceleration. OpenGL is a low-level API, so programming the code for loading models and camera setup was necessary.

A head model was downloaded from the internet [8]. The model is represented as an array of vertices, array of triangles and array of texture coordinates. Every point in space is an ordered triple (x, y, z), where x, y and z are coordinates of vertex along the suitable axes. Triangles are made up of three vertices and they are usually defined as integers which define the vertex array position because one vertex can be used in many triangles and this way there is no redundant data. Texture coordinate array is the same size as the vertex array, and each vertex has its texture coordinate. Texture coordinate is an ordered pair (u, v), where u and v determine positions on texture along x i y axis.

At the beginning program loads a face image. The image is being rendered on screen and the model is being rendered in front of the image. The bottom-left corner of the image is the origin and the top-right is the point that has x and y axis values equal 1, while z axis (depth) has value zero, as shown in Figure 2. This will enable easier coordinate mapping afterwards. The viewport is being set up as if the camera is positioned in front of the model, looking at the center of the image.

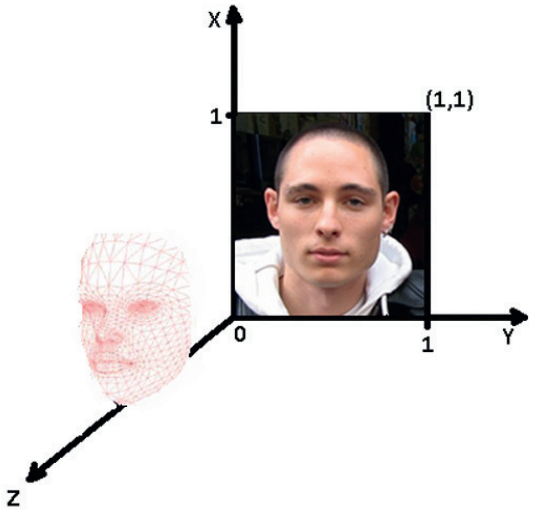

FIGURE 2. IMAGE COORDINATES IN 3D SPACE

Fitting the model and the image

The head model has its scale, while face image has its own. In order to make the model fit the image scale transformation must be applied to the model. Determining the scale will be done by manually selecting three points:

- Center of the left eye
- Center of the right eye
- Peak of the nose

The model will be scaled using the formula:

$$scale = \frac{((\text{imageLeftEyeY} + \text{imageRightEyeY})/2 - \text{noseX})}{((\text{modelLeftEyeY} + \text{modelRightEyeY})/2 - \text{noseY})}$$

The next step is rotating the model so that it is in the same pose as the person on the image. The first step is determining in what direction the head is being rotated in. For that we can use the fact that when a head is being rotated, the tip of the nose moves more than the two eyes, as shown in Figure 3.

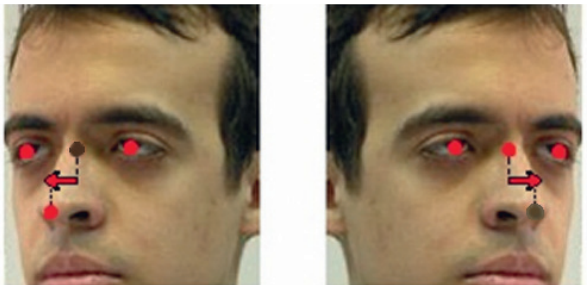

FIGURE 3. DETERMINING THE FACE ROTATION DIRECTION

Approximate rotation along Y axis is determined using the formula:

$$rotY = rotD \times \frac{90}{PI} \times \text{acos}\left(\frac{\text{imageLeftEyeX} + \text{imageRightEyeX}}{\text{modelLeftEyeX} + \text{modelRightEyeX}}\right)$$

Variable RotD represents rotation direction in equation.

OpenGL uses degrees for rotation, so rotation angle in the formula is being represented in degrees. After rotation, the model is being translated so that all the points have equal coordinates. Afterwards the head model is being manually fine tuned in order to fit the image as best as possible.

Determining texture coordinates

In order to map the texture to the model it is necessary to determine the texture coordinates for each vertex. Because the model is fitted on the image and the image has been placed so that all its pixels

fall within the range 0-1, texture coordinates will be determined by projecting the model on XY plane. This is done by multiplying the positional vector of a vertex with a projection matrix. Multiplying is done in homogenous coordinates, which means adding a scale factor as a fourth dimension of a vector. After multiplying, vector has to be normalized so that the fourth parameter has a value of one. A demonstration of a simple translation transformation is being shown in Figure 4. Projection matrix will be determined using OpenGL function which returns model view matrix: glGetFloatv with parameter GL_MODELVIEW_MATRIX.

$$\begin{bmatrix} 1 & 0 & 0 & dx \\ 0 & 1 & 0 & dy \\ 0 & 0 & 1 & dz \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = \begin{bmatrix} x + dx \\ y + dy \\ z + dz \\ 1 \end{bmatrix}$$

FIGURE 4. PROJECTION MATRIX

Hidden surfaces

When one looks at an image of a 3D object, one cannot see all its parts. If the object is a box, only its three sides out of six are visible at a given moment. The sides that are not visible are called hidden surfaces. Checking if surface is hidden is done by checking vertex order when projected on a 2D plane - surface is hidden if vertices are ordered counter-clockwise. Hidden surfaces cannot be mapped on a model, so we will use a mirror function to fill in those gaps. The model is symmetrical so we will determine a mirror vertex for each vertex in the model. While rendering the model, hidden surfaces will be rendered using mirror vertices.

Saving transformed image

After determining texture coordinates and hidden surfaces, all that is left is to return the model to its original position - facing camera, rendering it and saving the pixel data to a file for later use. While fitting the model we used only OpenGL transformations for projection, so returning the model to its original position consists only of resetting OpenGL model view matrix to identity matrix. Pixel data will be fetched using OpenGL function glReadPixels, and data will be saved in bmp file format which uses the same data format as graphics cards.

Program usage

The program shows the first image in database and the head model. User selects the three points: center of the left eye, center of the right eye and tip of the nose and the program fits the model approximately. If the result is not appropriate user can select the three points again. After that, the model is fitted additionally using keyboard. If the model is too wide or narrow it is possible to scale the model along X axis. The user can change model transparency at any time in order to see its position better. When fitted, pressing return button the texture is being mapped to the model. Once mapped, the user can turn the wire overlay on or off and rotate the model. After that the model is being brought back to en face position and newly made image is being saved to the hard disk. This process is shown in Figure 5. The loss of quality can be observed on the result image, on parts where mirror mapping is applied. This can be attributed to non-uniform lighting of the original image.

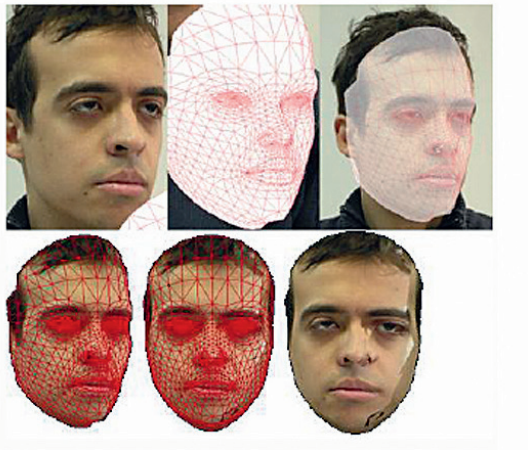

FIGURE 5. MODEL FITTING, ROTATING AND RENDERING

PERFORMANCE EVALUATION

All tests were performed on face database collected at the Faculty of organizational sciences [6]. Database consists of biometric data collected from 34 different persons. First collection of match scores was obtained by matching a base set of en face oriented photos with a set collected from same persons, in a similar way, six months later. Second collection of match scores is result from comparing base set with a set of images normalized by our program. Overall, we have done three types of comparisons:

- matching base set with en face images from later period
- matching base set with half profile images from later period
- matching base set with images normalized by our program (transformed from profile angle to en face)

Calculated match scores were used to draw ROC („Receiver Operating Characteristics“) curves, which allows us to visualize results. Figure 6 shows part of the curve on which the FMR (False Match Rate) value is lesser than 5 percent. Identification rate was also calculated.

Calculating identification rates leads us to following conclusions:

As expected, en face images have shown best performance. Twenty two persons were successfully identified (65%).

Because of changed angle of view, half profile images have shown significant performance drop. Only 13 persons were successfully identified (38%).

Normalized images have performed better than half profile images, but worse than en face. Twenty one person has been successfully identified, just one person less than enface images.

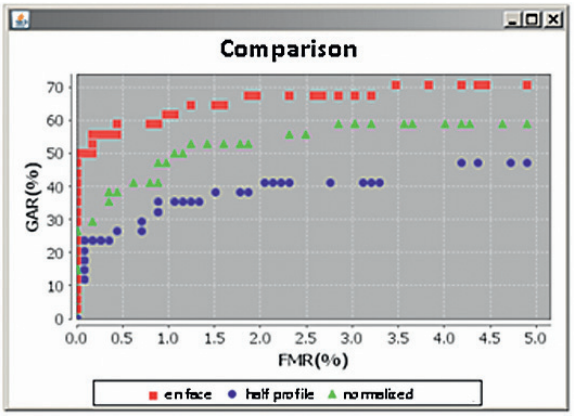

FIGURE 6. FACE RECOGNITION RESULTS

These results are encouraging since the improvement of face recognition algorithm is significant. On the other hand, it can be observed that the transformation is not perfect, since the results are not the same as original en face images comparison. This may be happening because head model is not flexible, or a consequence of loss of data from the side of the face that is turned away from the camera.

CONCLUSIONS

In this paper computer graphics techniques were used to improve face recognition performance. To evaluate proposed techniques, an application was developed. It allows us to transform two-dimensional photos to three-dimensional models. Three-dimensional model is then rotated in order to transform face images from profile to en face position. In this way, problems with camera angle are at least partially solved. Evaluation was performed on facial database collected at the Faculty of organizational sciences, and results have shown better precision after normalization of the photos.

For now, the process of model fitting is done manually, which means that human presence is necessary in order for system to function. Subsequent versions of the program should independently determine the position and angle of the head, which would automate the system. This automation would enable more intensive testing on larger databases.

Face model used for texture mapping is somewhat rigid and it is not flexible. It would be appropriate if all people had the same face shape, which is not the case. Face model should be fitted in accordance with facial features of an individual. Face specific parameters could be used for recognition, independently or together with other algorithms. Also, application should be extended to allow illumination normalization.

Acknowledgment

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E-textbook Development Capacities Within the Current Context in the Republic of Serbia

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Contribution to the state of the art

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Abstract: The study is a short sublimation of the e-book and e-textbook development. In digital age and with the adoption of new technologies, new educational digital platform has become an integral part of our everyday life and education which requires adjustments and changes in the educational system structure. In order to make the students be equal and functional members of the society and to prepare them for contemporary digital era, it is the entire society's most important responsibility to enable educational system to provide, in most optimal and proficient way, equal opportunities for each and every student to gain knowledge. Expensive process of a book digitalization will, in time, become economically acceptable for all in the broader community.

Key words: traditional book / textbook, e-book, digital textbook.

Introduction

The invention of Guttenberg's movable letters enabled book publishing to create a new era in the development of humanity and propagating the written word. The first book in print was the Bible. Contemporary printing development followed. In the state of Serbia, the first publishing house was in the Monastery of Rujan. The only book that was printed there was Rujan's gospel by monk Teodosije. Since founding of Guttenberg's print house in 1440 up to nowadays more than 100 million books were printed. One part of this huge production was digitalized, i.e. converted into electronic form. The technical part of the digitalization process is based on the scanning of the pages and generating the text search engine. Given that the book scanning is a convenient way of introducing advances into the work of public libraries – institutions which stimulate knowledge development, Guttenberg project launched in the year 1971, the avangarde of digital literal heritage development, stands out as the oldest [6].

In 1970s Michael Hart who had access to the network of the University of Illinois computer center (which had data processing for its primary purpose) invented data distribution through network. He had the Declaration of Independence in his hands and offered it for the users to download and this became the first e-book in the world. However, such a noble idea was not original: first efforts of recording text in a digital way had already occurred during the 1940s. Based on the project Guttenberg, the oldest digital library in the world, other projects sprung out.

Million Book Project was launched in 2002. It is an exemplary model of the international cooperation of the University of Carnegie Mellon and Internet Archive along with the institutions from India, China and Egypt [2]. The biggest and certainly most famous project is the Google Books Project. Not only did it allow digitalization of all kinds of literature (bibliography entries) but it also raised funds for digitalization.

Electronic/Digital Vs. Traditional Book/ Publication

Allocating funds is the key problem in book digitalization. Moving it to the massive level would be a capital project that employs contemporary technologies and requires huge economic investments. The goal of the mass digitalization project is to enhance the accessibility to literature as well as to information for greater number of users. Digital materials allow easy access and user-friendly file management: lower quality recordings can be enhanced, graphics can be scaled, document can be merged, rearranged, etc. Through generating such a database the search in different languages has been made possible and it also contributes to spreading of education, learning, scientific work and research; it prompts update to existing technology and developing of tech innovation. According to Borgman [1], we can discern between two ways of generating digital document: digital - made in digital form, and digitized - retyped or converted from some other medium such as paper, celluloid, etc. The final product of the digitalization process is a book in digital or electronic form (e-book). The e-book can be defined as a digital equivalent of the printed publication (contents of which can be reached through the network) or as „a file stored in solid medium (CD/DVD)" [3]. When compared to a publication in print, an e-book is more adaptable and accessible to the reader. It also enables editors during its production to employ a variety of formatting options whereby each has good and back sides. Some of the advantages which an e-book has include: the text is searchable except when pictorial, it does not occupy much of the memory space (one CD can compile 500 average e-books), it can be read with no additional source of light, easy to reproduce, the distribution price is low, it is affordable and ecologically acceptable (reduces the use of paper). Advantages of traditional publication compile: it can be read anywhere, even if damaged, it requires no power supply, has a vintage value (first editions). It is important to stress out that there are some downsides of both formats. The biggest fallacy of the e-book is its incompatibility with newer hardware and software, application can block the reading, careful management and storing of documents is needed in order to avoid data loss, battery can run out of power. Printing publication need a light source for reading, they are heavy to transport and harm environment by using paper and a copy production is more time consuming. Traditional publication can be owned by purchase, lent, borrowed, sold or given away while e-book cannot be sold or borrowed but we have to pay a lease for it as it belongs to the publishing house. Kindle allows readers to move it to another reading device for 14 days but we can no longer read it on our own gadget. E-book's quality, as well as traditional book's quality has to respond to specific norms. Those norms refer to individuals who are a part of the team in the production of a piece of work. Just like the traditional publication, a team of cooperatives except for the author includes an editor, proof-reader (whose task is to eliminate any spelling or grammar errors), art and graphic editor. It is important to stress that even the very format is an important reference: different e-book formats can impact the price depending on a device (e-reader) that is used.

E-readers are portable devices for reading books and other publications in digital form. Unlike standard screen which has a display based on backlight, the screen of the reader reflects the light in the same manner as it is reflected on the standard paper. That facilitates lengthy readings. There are some features that are in common for different readers: they are all easy to use, they are small in size (approximately 6 inches), they provide basic functioning options during reading (contrast, zoom, font alteration), and they do not display multimedia contents. Most famous are Kindle, Nook, Kobo; Most often used gratis applications are Adoble Digital Edition, Calibre, Readium as well as applications for specific mobile device platforms (Android and iOS) where the display is adjusted through font size alteration, screen orientation/rotation, different animated indicators of browsing, possibility of choice among 14 different languages. There is a huge variety of reading applications on the market. Among themselves they differ by functionality, file formats they support and sources of e-book retrieval. Free iBooks Apple application is opened for possibility of purchase form Apple Book Store as well as sharing marked excerpts by email, Facebook [7].

The outreach and development of digital publishing is closely related to the count of the e-gadgets sold

on a single market. In Serbia, we are facing the problem of lacking distributors of e-reader devices which are sold in the world for $69 and more. American Corner in Dom Omladine, Belgrade offers the possibility of renting e-readers but the offer is restricted to English titles exclusively. In Serbia, e-books can be purchased per single piece or consumed on year basis membership principle. E-book stores allow for local authors to publish their e-books and achieve global accessibility and success through presence in greatest global book stores. Digital markets of huge companies such as Apple, Google, Amazon, Samsung,... facilitate e-book distribution. Around 70% of traditional publication publishers cooperate with e-book stores which is very indicative when it comes to huge potential of sale and gain for the publishers and authors; simpler and cheaper production; distribution and accessibility for broad literary audience.

Digital Textbooks

E-book market development is infinite so a digital book breakthrough in the field of elementary education came as expected. E-book market has found its separate branch in classrooms. Textbook revolution/ digital text books offer one click solutions to complex problems in specific teaching modules. Multimedia contents, enriched with animations, quizzes and games, add value to traditional textbooks. Embedded multimedia presentation can last 30 seconds to 3 minutes. Through visual and audio illustration which traditional textbook is unfortunately lacking, it enables children's active participation in the class; it does not distract but rather enriches and enhances the process of adopting knowledge, research and apprehension. Everything is possible in digital world. New schooling possibilities: one click on shortcut on PC, tablet or smart phone reveals exclusive, safe and informative multimedia content. A digital textbook is always with a pupil. Wherever they are they can easily access it thanks to development of new technology. It also allows constant accessibility of all the contents, notes, bookmarks, interventions introduced for more productive learning, to be updated and adjusted to all the devices on which the e-textbook is installed. Digital textbooks are based on methodic rule which is familiarly organized and makes easy browsing and navigating through contents and it allows a student to use it along with material in hard copy. Pages can be browsed linearly same way as with traditional textbook but also chapters can be skipped through browsing, contents can be searched through key words that are found on each page where occurring. Every digital textbook can comprise audio and video files, quizzes and interactive objects, images and photo galleries, as well as documents like ppt presentation, URL, links to referential contents elsewhere in the text. Student is also free to highlight the text in different colors, to draw and paint, to store it all in one particular place, to erase or to export into a separate document saved on his/ her personal computer. One can also take notes, add contents retrieved from Internet, save together in one folder or export into a separate one. With digital textbook everything is accessible to everyone. Conditions of learning are equal for all. Equipped lab or classroom can add value to the integration of good digital textbook. It is important to discern digital textbooks that solely compile PDF pages identical to ones found in hard copy textbook (traditional textbook scanned) from digital textbooks which, except for that text, are also enriched with visual and multimedia illustrations.

Digital textbook has additional contents in the form of video recordings, animations, pictures, interactive quizzes. Therefore an interactive digital textbook that is yet to be introduced into the curriculum can open new possibilities for its users. By using multimedia, the digital age allows for the curriculum to be presented to learners in a well-organized, comprehensive and inspiring way. It also enables them to gain higher degree of intellectual development and autonomy; it boosts their self-esteem due to the fact that in a short period of time the required information is found. It also inspires curiosity and explorative spirit which are essential nature of the learning process. 3D technology allows elevated apprehension in presenting chemistry, physics, geography related learning units. Successful educational platforms and process management system that are employed in the contemporary school system are, for example, Desire2Learn, Learning Hub, and Blackboard. We need to keep in mind the fact that the world around us as well as the future of our children are in their nature digital. Thus new learning environment and pedagogic paradigm shift are imposed. The new concept requires cooperation within multidisciplinary teams

that are to adopt components of technologic innovation relevant for the educational system. Such a process also alters the role of the teacher from primary information provider towards someone who facilitates students' understanding of complex processes and discerning information by priority within huge amount of data brought by digital era.

Digital Schooling In The World And In The Neighboring Countries

The educational system of one country is based on the knowledge which is the basis for technological development enabling us to find necessary information. Therefore, in the new tech age the educational system requires a new model of passing the knowledge from a teacher to a student. E-textbooks, e-schooling and e-education are exemplary models of education and technology interaction. Digital technology enables new and relevant social dimension in the process of education. It strives towards accentuating the individual approach and technical literacy necessary for independent use of available sources of knowledge and information. Higher flexibility degree and students' interactive approach to digital contents are only one among numerous features of digital technology that can be appropriately incorporated in the process of education. The importance of digital age in education was first recognized by South Korea. In 3006 the Smart Education Programme was launched with the mission to fully replace traditional elementary, high school and college textbooks with the digital ones by year 2015. Based on prior experience, they have found an optimal model which combines traditional and digital textbooks for lower grades of elementary school. In 2012 The Playbook manual was published in USA. It compiles suggestions for the steps toward digital textbooks implementation. Backed up by those guidelines, some of the states, 40 of them, have enacted regulations and issued recommendations for ways to organize digital schooling (Florida set 2015 as its goal to have all the textbooks produced in digital form; for every pupil in higher grades of elementary school and high school the state of Alabama provides tablets with digital textbooks...). Digital educational revolution is an Australian project launched in 2011. In 2010 Japan launched the project School of the Future which has the aim to provide a free tablet for each pupil and Smart Boards in Classrooms for every school. It is also worth mentioning that China, India and Israel have launched similar projects. Such a trend is also followed by the majority of the EU countries. In the neighboring countries the situation is as follows: in Croatia, Školska knjiga and Profil stand out in the field of digital textbook production; [5].

Macedonia has launched a portal with e-textbooks in 2010. [8]. In Serbia, supplementing material for textbooks for elementary and high school education is released in the interactive form on CDs by Serbian state publisher of textbooks.

E-textbook as an equivalent of traditional book and comprising multimedia contents, adds to the quality of education and marks the trend of overall social development. On the other side, a complex process of layout design and production in printing traditional textbooks slows down the process of curriculum modernization. The modernization is also in need of investments from the part of state and society. Laptop for every child was a developing project launched in 2002 as a part of aid that USA and western counties provide for developing countries. The project, initiated by professors from famous MIT, has for its mission easier access to learning and to information for all the children. By producing a simple and cheap laptop that could be given away, all students in developing countries would have had better access to education. The statistics shows that around two billion kids in the world cannot afford access to appropriate education and that there are countries with education budgets which do not allocate more than $20 per pupil. So, such an initiative would not only be humane, but would also produce a positive long lasting impact on social and economic development of those countries. In United States, the educational system in one part operates online only and also offers free educational material. The fact which cannot be ignored is that $7500 is allocated per child from the budget for education.

At this moment, the development of digital textbook platform in Serbia demands high investments in education as well as enacting legislation which would define the status of digital electronic textbooks. The

platform development would imply logging in by using personal username (password) which would be unique for each student and teacher and also valid for e-textbooks and e-worksheets purchase in e-book stores. A textbook in electronic form identical to the hard copy would be a transition towards next digital textbook development phase and it would be followed by adding multimedia contents. Expanded reality, as virtual and our surrounding realities brought together, is a novelty. It is technology which on e-book or smart phone screen displays real world information and computer generated images and contents combined together. This technology operates through software which uses camera to identify an object (*tracker*) which is replaced with some virtual object or set of information [9]. By means of special application installed on a mobile phone and scrolling over tacker additional information is opened as well as video records in a traditional textbook. Digital textbook has to respond to the needs of the educational process (text highlighting, inserting/adding notes, writing homework, etc.) everything that would otherwise be done on the paper in the school and at the same time it has to be enriched with multimedia and hyperlinks. Development of such a platform (for tablets for example) not only that complies with the current technological trends but it also decreases textbook purchase expenses by 50% and it also reduces the weight of a schoolbag. That way, the publishers would decrease production expenses for textbooks because layout design, printing, storage and distribution costs drain the budget. By introducing e-textbooks into educational system the earnings of authors and publishers would not decrease in value. As World Health Organization recommends schoolbag should not exceed 10% of the weight of the child who carries it. By using tablets instead of traditional textbooks the weight of the schoolbag would reduce to couple of hundreds of grams. To the contrast, nowadays schoolbags carry few kilograms of load. The practice shows that change is slowed down since compulsory and not so important textbooks (which children carry in their schoolbags on daily basis) are still being published. Besides becoming an integral part of our everyday lives and heading toward digital textbook field expansion, the development of digital technology is on its good way to change basic educational system concept, too. The development of digital textbooks is one of the steps in the educational system modernization which depends on the state legislative. The assistance of the state is necessary through the modernization of regulative, financial support for parents when purchasing tablets, modernization of classrooms so that students would take part in contemporary tech progress and become members of a quick and simple learning community.

Legal Regulative/Regulations

One of the issues arising when it comes to e-book is protecting copyright from unauthorized download of electronic content as well as charging the fee for using it. In the beginning, the nonprofit publishers were thrilled with the Google Books projects' possibility to allow access to numerous rare and desired books. But from the fear of copyright infringement as well as losses in publishers' profit, many questions which were not regulated have arisen. The length of snippet, a number of copies which Google can make, ways of the distribution, influence on the work of libraries and bookstores, monopolization of access to information were all the issues needed to be resolved. As the majority of criticism referred to a case of copyright infringement (which ended up in the judicial procedure), in 2008 Google paid 125 million of dollars as a compensation for the digitalized books protected by the copyright laws [10].

In its base of digitalized books with expired copyrights (which are, in the case of USA, all titles published before 1923) Google has provided free access to entire contents, while books protected by the copyright laws can be accessed for a limited period of time. Over time, the European countries like Austria, Belgium, France, Germany and Italy have also joined the Google project. The first Serbian author whose books were published in the electronic form was Milorad Pavić. He was also among pioneers advocating the online and electronic models of book publishing.

In Serbia, the number of titles that are available in electronic form is rather modest. The crucial problem is the copyright but also lack of professional e-book publishers and the fact that only some scientific literature and magazines are accessible in their full form. KOBSON – the system with more than 38.000

foreign magazines and over 50.000 titles allows access to e-documents for scientists, researchers and all that are interested. The National Public Library, in an e-format, mostly has the titles with the expired copyright which means that the modern titles are outnumbered by far. According to the Compulsory Provision of Publication Copy Act [4] each publication meant for release is delivered to the Library in its digital form. The primary motive is to have all the titles that are printed accessible in electronic form too. E-book is revolutionary achievement in publishing business/trade. Its development is almost incalculable. By summing all the expenses of hard copy book production in Serbia, we may come to conclusion that the scene is beyond profitable: the high expenses of printing and distribution have made traditional books inaccessible for numerous readers. Alternative to that is development of e-book because expenses of its productions are around €1. In this manner, the production expenses problem is resolved, a book becomes more accessible to a reader, titles and authors are more easily promoted, the knowledge basis expanded and the intellectual capital of a society is enlarged as well as the profit. What statistics shows is that Amazon, the world largest bookstore, annually sells more books in the electronic format than paper ones.

Conclusion

The arrival of an e-book in Serbia is belated. Nevertheless, it is the reality which will soon, just as any other world trend, become a part of our culture. The climate in Serbia suggests that e-books will soon assume position dominant to traditional publications. Research analyses indicate that excellent, bestselling e-book titles also have found their audience among traditional book readers. At this moment, the cultural mission of e-books mostly depends on the speed and quality of finding solutions to problems which comprise copyright, distribution and others. The Tribunal for High-Tech Crime of Serbia is disbanded; the digital piracy issues are resolved through execution of the contracts with huge systems, distributers and publishers which take care of the piracy problem. Over the past years Serbia has been facing the problem of illegal copying of certain titles through Xeroxing. Through e-publishing development a book becomes more accessible and cheaper so the need for Xeroxing declines.

Over the past years e-books dominate in developed countries while in Serbia, due to economic limitations and lacking popular literacy in informatics, the progress is staggering. Even though we live in the age of high tech development the impression that we are still at the beginning persists. It is backed up by the fact that we have numerous unresolved issues when it comes to the legal and economic aspects of the new technologies' employment. In order to gain status of an equal member within the technology age community which we live in, we have to be ready to conform to benefits offered by the future of informatics.

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Hybrid Methodology of Nonlinear Goal Programming

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Contribution to the state of the art

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Abstract: What we demonstrate here is a nonlinear goal-programming (NGP) algorithm based on hybrid connection of the modified simplex method of goal programming, gradient method of feasible directions and method of optimal displacement size finding-called HNGPM. Iterative methodology is given in five steps: (1) linearization the set of nonlinear constraints at particular point, (2) solving the problem of normalized linear goal programming, (3) feasible direction computation, (4) calculating optimal step length displacement, and (5) testing out convergence problem. Our idea was to apply Euler's theorem for the "total" linearization of the nonlinear constraints (in the space) around particular point. According to Euler's theorem, it is possible to apply this methodology to solve the problems of NGP whether the nonlinear constraint functions are linearly or positively homogeneous.

Keywords: Non-linear goal programming, Cobb- Douglas's production function, Euler's homogeneous function theorem, feasible directions method

Introduction

Here we use multi-objective optimization (also known as multi-objective mathematical programming) where the set of feasible solutions is not explicitly known in advance but it is restricted by constraint functions. Here we concentrate on nonlinear multi-objective optimization where at least one function in the problem formulation is nonlinear and ignore approaches designed only for multi-objective linear programming problems where all the functions are linear. In multi-objective optimization problems, it is characteristic that no unique solution exists but a set of mathematically equally good solutions can be identified. These solutions are known as non-dominated, efficient, non-inferior or Pareto optimal solutions.

Typically, in the Multicriteria Decision Making literature, the idea of solving a multi-objective optimization problem is understood as helping a human decision maker (DM) in considering the multiple objectives simultaneously and in finding a Pareto optimal solution that pleases him/her the most. Thus, the solution process needs some involvement of the DM in the form of specifying preference information and the final solution is determined by his/her preferences in one way or the other. In other words, a more or less explicit preference model is built from preference information and this model is exploited in order to find solutions that better fit the DM's preferences.[1]

Goal programming (GP) has proved to be an effective approach in facilitating decisions involving multiple objectives. Distinct from many other mathematical programming techniques, goal programming is able to overcome many limitations present in solving both single and multiple criteria problems.

The objective function of GP is minimization of positive and/or negative deviations from a set of goals determined by decision maker. Due to the fact that preventive priority and numerical differential weights are used, the difficulty of a priori estimation

of a single objective is avoided. Besides, other multiple criteria decisions making requires approximation of weights for obtaining an objective function. However, the task of rank ordering some priority goals in goal programming is much easier for decision maker than assigning weights, because it approximates the actual decision making process.

Instead of determining an optimal solution in the manner of linear programming (LP), solutions based on GP satisfy ordinal priorities assigned to the goals. These solutions clearly point out: which goals can or cannot be achieved, the amount of underachievement connected with every unachieved goal, and the tradeoffs among the goals, so called Pareto optimum.

When comparing with the other management science techniques, GP could be characterized as a practical oriented application tool. It means direct help for decision makers, as well as effort for decreasing strict requires in ordering structural priorities in one form, which most of known multiple criteria methods of deciding are already familiar with.

In managing practice, we consider great number of problems as linear, but if we try to get to the base of problem, it will be discovered that they are nonlinear, and linearity is just an approximation. In problems of non-linear programming (NLP) the linearity could be subject either in constraints or in function criteria, or in both.

At LP the sphere of possible solutions characterizes convex set created on cut of the final number of linear constraints, so the possible problem solution is only the final number of extreme points. However, when at least one constraint is nonlinear equation, existence of no final number of extreme points is possible, or the solutions are located in no convex area, so there are many possible solutions of one problem. In many cases, there is no guarantee that the final solution generated by nonlinear goal programming (NGP) algorithm is the optimal solution unless certain conditions for the shape of the objective function and structural constraints are satisfied.

Nowadays, the great number of different methods for NLP solving problems is developed. One of the special group methods are numerical solving methods, in which the most important place takes methods of so called direct search, and then the gradient method.

In order to develop an algorithm for solving NLP models where Cobb-Douglas type nonlinear constraints exist, we have constructed one new gradient NLP algorithm with feasible directions methods built in, methodology named HNGP (Hybridized Non-linear Goal Programming). This methodology is based on linear GP algorithm and feasible directions methods. Using Euler's Homogeneous Function Theorem, HNGP makes linear each nonlinear homogeneous constraints function in the area of some particular point. [2]

METHODOLOGY CONSTITUENTS

The problem of nonlinear goal programming (NGP) can be expressed in the following way:

$$\text{Min } F(d) = \sum_{l=1}^{k}\sum_{i=1}^{n} w_i P_l (d_i^- + d_i^+) \quad (1)$$

subject to:

$$G_i(x) = \sum_{j=1}^{n} g_j x_j + h_j \prod_{j=1}^{n} x_j^{e_j} + d_i^- - d_i^+ = c_i \quad (2)$$

$$A_i(x) = \sum_{j=1}^{n} a_{ij} x_j \le b_i \quad (3)$$

$$x_j, d_i^-, d_i^+ \ge 0, \text{ for all } i=1,\ldots,m, \; j=1,\ldots,n. \quad (4)$$

Where x_j are decision making variables, d_i^- and d_i^+ represent negative and positive deviation variables from the goals (underachievement and (overachievement), respectively. The g_{ij} are coefficients of linear portions of goals (constraints (2), a_{ij} are coefficients of structural constraints (3), h_{ij} are coefficients of nonlinear portions of goals (2), and e_{ij} are components. The c_i and b_i are constraints of right side in (2) and (3) respectively.

P_l in objective function (1) is preventive priority factors, so the following is valid:

$P_j >>> P_{j+1}$ for all j = 1, 2, . . . , k.

The highest priority is indicated by P_1, the next highest by P_2, etc. The w_i are weights assigned to some priority factors. The model of priorities means that P_1 is preferred than P_2 regardless of any weights w_i associated with P_2.

Euler's homogeneous function theorem

Homogeneous function is a function which has an attribute that for any real constant λ satisfies $F(\lambda x,\lambda y) = \lambda^n f(x,y)$, for a fixed n. Then we say that function F is homogenous by degree of homogeneity of n. If n>0, the function is positively homogeneous; if n=1, the function is linear homogeneous.

Example: The function
$z = f(x,y) = 3x^4+2x^2y^2+7y^4$
is homogeneous of degree 4 since
$f(\lambda x, \lambda y) = 3\lambda^4x^4 + 2\lambda^4x^2y^2 + 7\lambda^4y^4 = \lambda^4(3x^4+2x^2y^2+7y^4) = \lambda^4 \cdot f(x,y)$

If z=f(x,y) is positively homogeneous of degree n, and the first-order partial derivatives exist, then it can be shown that:

$$x\frac{\partial z}{\partial x} + y\frac{\partial z}{\partial y} = nf(x,y)$$

That is:

$$f(x,y) = \frac{1}{n}(x\frac{\partial z}{\partial x} + y\frac{\partial z}{\partial y})$$

This relation is known as Euler's homogeneous function theorem.

Example: According to Euler's theorem, for the function

$z=f(x,y)=3x^4+2x^2y^2+7y^4$

it is valid:

$$x\frac{\partial z}{\partial x} + y\frac{\partial z}{\partial y} = 4f(x,y)$$

which can be verified as follows:

$$x\frac{\partial z}{\partial x} + y\frac{\partial z}{\partial y} = x(12x^3+4xy^2) + y(4x^2y+28y^3) = 12x^4+8x^2y^2+28y^4 = 4f(x,y)$$

In majority of up-to-date developed methods used for solving NGP problems, the most significant one of this very type is the gradient method combined with the feasible direction method [3].

The feasible directions method

The definition of a feasible direction reads: given a feasible point x, a direction vector d, is feasible if there exist s>0, so that x+sd is feasible

The feasible directions methods have been primarily intended for NGP and they are the iterative ones whose solutions in certain iterations have the following recursive form:

$x_{p+1} = x_p + l_p s_p(x)$ for all p=1,2,…,m

where $s_p(x)= s(x_0,x_1,x_2,\ldots,x_p)$ is direction and $l_p \geq 0$ is a step size, which is chosen so that:

$F(x_p + l_p s_p) \leq F(x_p)$ for all $(x_p + l_p s_p) \in X$, and $0 \leq l_p \leq 1$, $s_p(x) \geq 0$,

And where:
$X = \{x \in R^n,$ and conditions (2), (3) and (4) are satisfied$\}$
If l_p is chosen in this way, it follows that all points between x_p and x_{p+1} are feasible.

Direct search NGP based methods utilize some type of logical search pattern or methods to obtain a solution that may or may not be the best satisfying solution. The logic process is based on repeated attempts to improve a given solution by evaluating its objective function and/or goal constraints.[4]

Gradient methods use the gradient direction as a direction for improving solution, thus defining the feasible and usable feasible directions, including reduction of the nonlinear problem to an approximate linear problem which is close to the initial one or some other by iterative set solution proceedings.

The method is iterative and each iteration starts with an initial feasible vector. In great number of iteration of the feasible direction method, feasible directions of improvement (usable feasible directions) are determined and a new "better" point is found out in that direction. Optimality is achieved when no further improvement can be made in any feasible direction.

To calculate the gradient, this method requires functions that are continuous and differentiable. In

order to guarantee convergence of the algorithm the gradient method requires that the model constraints find a convex set at each goal level while the objective function is concave.

Many methods for solving linear or non-linear programming problems are developed based on feasible directions method. The only difference exist in extra requirements for fixing the initial point x_0, the directions $s_{k,}$ or the step lengths l_k.

The gradient of Cobb-Douglas's production function

In this case we are particularly interested in a nonlinear function of the Cobb-Douglas type, which general form is:

$$f(x_1, x_2, ..., x_n) = h\prod_{i=1}^{r} x_i^{b_i} \quad (5)$$

where: $x_i \geq 0$, for all $i = 1,2,..., n$, are independent variables, $h \in R$ is coefficient, and $b_i \in R$ are exponents of independent variables. This is most similar and most frequently applied form of production function by which the production is rated in a certain economy, expressed as a function of labor and money investment.

In accordance with Euler's homogeneous function theorem conditions, it has to be noted if $f(x_1, x_2, ..., x_n)$ is homogenous of degree r and the initial derivatives exist, than it can be shown that is:

$$f(x_1, x_2, \ldots, x_n) = \frac{1}{r} \sum_{i=1}^{n} \frac{\partial f(x_1, x_2, \ldots, x_n)}{\partial x_i}_{[x_p]} \cdot x_i$$

where is with $[x_p]$ denoted "in particular point x_p", and where for Cobb-Douglas's functions (5):

$$\frac{\partial f(x_1, x_2, \ldots, x_n)}{\partial x_k}_{[x_p]} = hb_k x_k^{(b_k - 1)} \left(\prod_{\substack{i=1 \\ i \neq k}}^{n} x_i^{b_i}\right)$$

for all $x_i \geq 0$ (6)

are the coefficients of linear constraints calculated in particular point x_p (denoted as).

HNGP methodology

The main idea of HNGPM is that no linearity of constraints set, using Euler's homogeneous function theorem, linearize in the neighbor of point x_p (float feasible solution). Then, using modified simplex linear goal programming method, one could find a feasible direction L_p. Subsequently, using one direct displacement along the feasible direction step length searching procedure, we find out optimal step length s_p in that feasible direction such is the approximation valuation made by linearity in this new point and in satisfied limits of accuracy. This procedure is iterative and repeating until the shift made in one of the next iterations would be less than of convergence criterion

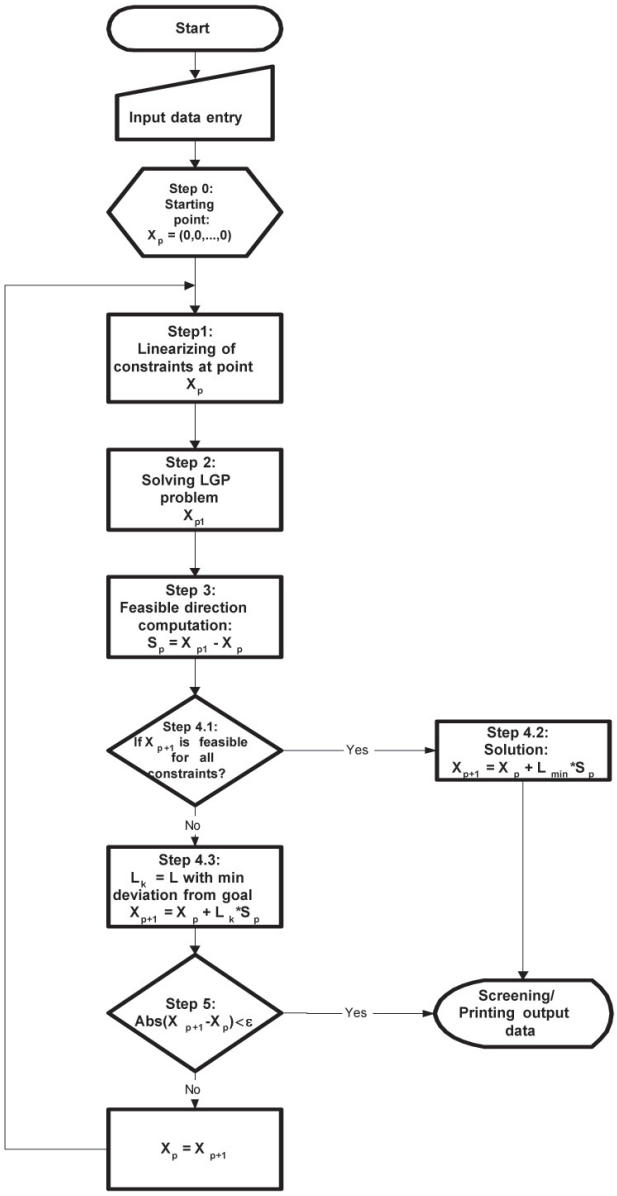
Algorithm of HNGPM

Algorithm of HNGP is based on hybrid connection of modified simplex method of GP, gradient method of feasible directions, and method of optimal displacement size finding. Concerning this problem, the objective function is linear and only a few constraints are nonlinear, the procedure is simplified when compared with general convex programming problems.

Iterative proceedings are given in six steps with an initial step (Step 0) used only at the beginning, i.e. in the initial iteration (Picture 1).

The initial step sets all vector solution values to zero and uses this point as origin x_0. In this point all nonlinear portions gradient values of the goals are equal to zero. This reduces the problem of NGP (problem of (1) to (4)) to linear approximation solvable by the modified simplex method of linear goal programming.[3]

The first step of an HNGPM algorithm is the computation of gradients of all constraints together with checking the status of nonlinear constraints in order to (if need) deflect, the gradient of active (binding) nonlinear constraints.; to avoid zigzagging, which is often possible in solving problems algorithm of NLP. Without this deflecting, the algorithm may converge upon a sub optimal point.



In the second algorithm step we solve normalized NGP problem of (1) to (4), that is:

$$\text{Min } F(d) = \sum_{l=1}^{k}\sum_{i=1}^{n} w_i P_l (d_i^- + d_i^+) \quad (7)$$

subject to:

$$G_i(x) = \sum_{j=1}^{n} \nabla g_{ij}(x_p) x_j + d_i^- - d_i^+ = nc_i \quad (8)$$

$$A_i(x) = \sum_{j=1}^{n} a_{ij} x_j \le b_i \quad (9)$$

$x_j, d_i^-, d_i^+ \ge 0$, $d_i^- \cdot d_i^+ = 0$, for all i=1,…,m, j=1,…,n. (10)

and where sign $\nabla g(x_p)$ denotes the gradient of nonlinear constraint function in particular point x_p calculated by (6). That is, nonlinear constraints are transformed to linear on the basis of Euler's theorem computed gradient value in point x_p (in the initial step it was x_0).

In this step linear goal-programming specified problem (7) to (10) is solved by modified simplex method of linear goal programming. This method of linear goal programming derives the feasible solution x_p.

The third algorithm step serves for feasible direction $d_p(x)$ computation:

$$d_p(x) = x_p' - x_p$$

which has to be "searched" according to the constraints and structure of priority in order to improve the simplex solution.

In the fourth step, the optimal displacement step size of the solution vector is determined by linear searching along with feasible direction identified in the previous step. In this way, first the structural constraints $A_i(x)$ must be satisfied and, after that, the goal ones, starting from the goal constraint $G_i(x)$ from (2) which contains the deviation variable with top priority (P_1) in the objective function of the NGP problem, minimum deviation in the function criterion, and then other priorities in lexicography importance order (P_2, P_3, itd.).

To perform the search and to prevent infinite moving in the cases of unlimited problems, it is necessary to determine the lower and upper displacement limits in feasible direction and unit displacement size (increment) within these limits.

The convergence of this very problem, speed of convergence, and other algorithm features depend on the choice of vector $s_p(x)$ and limits for the step size s_p. In initial step the lower limit of s_p in the algorithm was set to 0 and the upper to 1. If it is necessary it is possible to set them differently. The unit displacement size in the algorithm was set on 0.1 at first, but it is possible to increase the search density.

Using these procedures, we define whether the

first goal constraint (per priority and not per order) is satisfied within the initial limits. If it is satisfied at some short interval $[s_{pl}, s_{pd}]$, for all $s_{pl} \geq 0$ and $s_{pd} \leq 1$, the search for the further goal constraint goes on exclusively within this interval as its satisfaction, in accordance with Pareto optimality, cannot be sought to the detriment of satisfaction of a higher priority goal.

If we during the algorithm search come across goal constraint that could not be satisfied in limits of feasible directions set for previous higher priority, then within these limits the algorithm identifies the value of displacement size for which the deviation from the subject constraint is the least s_p $(0 < s_p \leq 1)$, we complete the searching and compute the new solution (successor) as follows:

$$x_{p+1}=x_p+s_pL_p(x_p)$$

If all constraints are satisfied, then the new solution is at the same time the optimal solution to this very problem.

In the fifth algorithm step we check the problem convergence by previously set small value of the desired level of convergence accuracy -- ε:

$$|(x_{p+1} - x_p| \leq \varepsilon, \text{ for all } p = 1,2,\ldots\text{etc.}$$

which means that the problem has converged and the algorithm finalized its work. Otherwise, the optimum search procedure continues beginning with the first algorithm step.

CONCLUSIONS

The idea of linearization of nonlinear constraint and solution of nonlinear programming problems is not new, because Griffith and Stewart (in 1961) first suggested that nonlinear problem may be linearized around the particular point by expansion as a Taylor's series, ignoring elements of a higher order than linear and adding two more restrictions for each nonlinear constraints. In that way, nonlinear programming problems have been transformed into a form which can be solved by the linear programming methods. However, there are other optimal methods which can solve programming problems in which nonlinear constraints are not Cobb-Douglas type. Yet, among them are very small number of nonlinear multi-criterial programming methods, especially goal programming.

Our idea of HNGP methodology was to apply Euler's theorem for the "total" linearization of nonlinear constraints around the particular point. This methodology was possible using this very theorem, as well as its utilization for solving nonlinear goal programming problems. In economic theory, the production function is frequently assumed to be linearly homogenous, because such functions have convenient characteristics. Although HNGPM is a numerical methodology for solving only certain types of NGP problems, it could be extended to solve other nonlinearly constraints forms.

In general, HNGPM methodology is used for solving nonlinear goal programming problems in which constraints are given by other homogeneous, continuous and differentiable functions. The only request the algorithm should obey is to do special subprograms for computing of nonlinear function gradient, and computing vector solution.

The advantage of our approach is unnecessarily adding two new constraints in every simplex iteration algorithm for every linearization of nonlinear constraint. Another advantage is that linearization of nonlinear constraints is more precise, with which algorithm along with other necessary conditions of convergence the problem solution is found more rapidly.

This work shows that with using Euler's theorem it is possible to perform hybrid connection of feasible directions gradient method with linear goal programming method, and create brand new methodology. These resultants are opening new possibilities for further hybridization of nonlinear goal programming method, and creating new and more effective methodologies options, as well as setting of interactive programming.

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AQUACULTURE CLOUD MANAGEMENT SYSTEM

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Contribution to the state of the art

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Abstract: This study proposes an aquaculture system combining wireless sensors with the Internet of Things and expert system concepts. Built on the accumulated expertise and experience of professionals and researchers, the knowledge base advises aqua-farms on relevant farming practices. We hope that this system will conserve resources and secure product quality. The system also provides production data to consumers, thus facilitating information transparency and allowing consumers to purchase products with full knowledge and guarantee of food safety.

Keywords: Expert system, Internet of Things, Cloud services.

INTRODUCTION

As technology and medical sciences advance, the public has become increasingly concerned with food hygiene, quality of life and prevention of illness (Fig. 1). With no sign of slowing in global population growth, there is a need to forecast consumer demand for aqua-farm products. Global marine yield has declined in recent years, as the proportion of overfished species increases and under fished species are neglected. The global fishing industry is facing an unprecedented bottleneck.

FIG. 1. – 2009 YIELD FROM WILD FISHING AND AQUA-FARM INDUSTRIES

A majority of seafood in Taiwan comes from enclosed aqua-farms. The farming process is not only labour-intensive but also leads to problems such as over-pumping of groundwater, ecological damage and subsidence due to poor management. Traditional fish farms use electric motors –or, at an even earlier point in time, water wheels - to change groundwater. As governments worldwide promote energy conversation, these practices could be argued to be a waste of power and water resources. Using automated mechanisms in place of traditional methods for routine farming activities (with inspections on an irregular basis) would save electricity and manpower, as well as reduce farming risks.

Our objective was to design a cloud management system for aqua-farms that would facilitate 24 hour monitoring of facilities while reducing consumption of resources. We interviewed experts on aqua-farming and collected data which was compiled and stored in the database. The inference engine was then used to store the data in the knowledge base, achieving the aim of knowledge management.

Using the Internet of Things concept, we employed sensors to monitor the aqua-farms, allowing

personnel to keep tabs on the facilities at any time. They can also search for solutions to problems via the cloud management system, and record and report the results, thus maintaining the usability and effectiveness of the system. We hope that the aqua-farm cloud management system will achieve the following goals:

1. High quality aqua-farming results: Consistent quality that is not affected by differences in time, region or species.
2. Conservation of resources: We recruited industry experts and academics to regularly maintain and update the data in the knowledge base. If aqua-farmers operate their businesses based on the guidance provided by the knowledge base, they will be able to conserve resources and improve their efficiency.
3. Transparency: The public is increasingly concerned over food safety. The system can upload data on the aqua-farming process to a public cloud, through which consumers can access production-relevant information.

As Fig. 2 shows that we hope to conserve resources and reduce costs through the aqua-farm cloud management system, as well as enhance industry competitiveness and maintain the quality of aqua-farmed products, thus maximizing allocation of resources and benefiting local aqua-farmers.

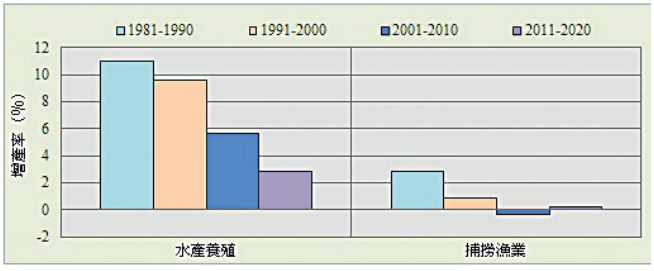

Fig. 2. Global growth in wild fishing and fish farming industries

Literature review

Expert system

An expert system is simulated judgment and behavior of a person or an organization of professional knowledge and experience in specific areas of computer programs. This system includes a knowledge base comprising knowledge and experience accumulated to be applied to the program described in each specific case of a set of rules. Expert systems can be complex and increase the knowledge base or the set of rules is enhanced (Fig. 3).The development of expert systems has changed dramatically in recent years and it is based largely on concepts dealing with artificial intelligence. These efforts are evolving from very specific, academically oriented efforts, such as medical diagnosis, to more managerially oriented corporate issues. Unfortunately, many proponents of these systems may be overlooking possible legal ramifications related to both the development and use of these systems[5]. The use of computers to process data began in the 1970's. By the 1980's, the trend had begun moving towards knowledge processing, as computer functions were gradually developed to mirror the functions of the human brain. Many studies have found that the anticipated performance benefits of using an expert system-such as increases in decision quality or speed of decision making-can lead to increases in expected usage. At this point, a milestone concept – artificial intelligence – was born, the most commonly known application of which is expert systems [1]. Expert systems solve problems raised by users through repeated inferences using relevant data in the knowledge base. Building the inference engine and knowledge base of an expert system is a daunting task [2].

Expert systems can have some disadvantages[13]:

1. Cannot easily adapt to the environment.
2. Expert systems are more professional, ordinary people cannot be easy to use.
3. Expert systems do not have the basic knowledge.

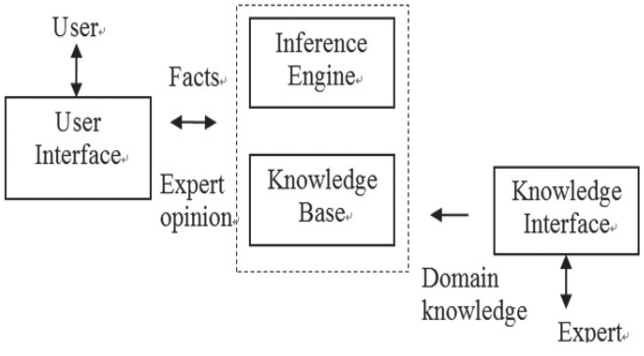

Fig. 3. Expert system

- User interface: Communication channel between system and users
- Inference engine: Extracts the facts from the knowledge base and finds the most appropriate answer [7]
- Knowledge base: Stores and categorizes the solutions provided by experts
- Knowledge interface: Converts and stores the experience and skills of experts as the knowledge base [12]

Internet of Things

The Internet of Things (IoT) provides anywhere, anything, anytime connections for which user privacy is vulnerable and authentication methods that favour policy over attributes are essential[14]. However, the term "Internet-of-Things" is used as an umbrella keyword for covering various aspects related to the extension of the Internet and the Web into the physical realm, by means of the widespread deployment of spatially distributed devices with embedded identification, sensing and/or actuation capabilities[10]. Underpinning the development of the Internet of Things is the ever increasing proliferation of networked devices in everyday usage. Such devices include laptops, smart phones, fridges, smart meters, RFIDs, etc.

Radio Frequency Identification RFID is a non-contact automatic identification technology, which signals through radio frequency automatic identification and access to relevant target data, no need for manual intervention to identify job, can work in a variety of harsh environment[11]. The Internet of Things uses RFID technology and sensors to join physical objects into an Internet-like structure, the aim of which is to support interaction between identifiable objects [8]. Mechanisms such as RFID technology, wireless detection and embedded smart chips are used to exchange information on physical objects [9]. The Internet of Things consists of three layers (Fig. 4): sensory, network and application. The sensory layer monitors the environment through sensory devices (for example, through volume perception).

The main function of the network layer is to transmit the data collected in the sensory layer to the data centre using wired and wireless networks. Lastly, the application layer applies technology to provide the desired results based on the needs of different industries.

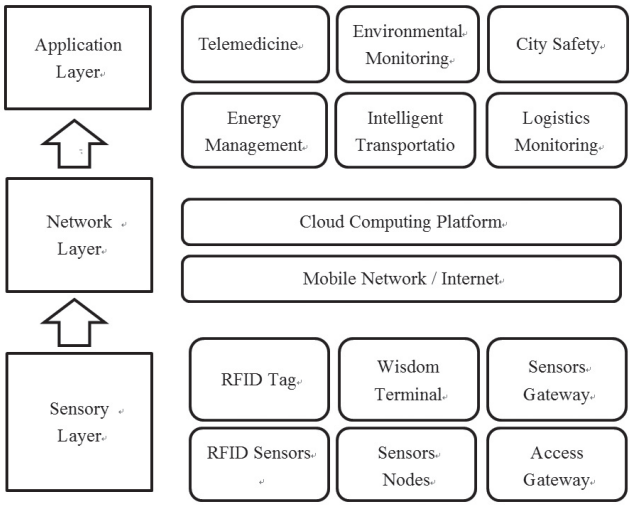

Fig. 4. RFID architecture Data source: Institute for Information Industry

Traceability

Consumers worldwide have become more concerned with the safety of the food they consume. The Food Traceability System has been introduced in many countries to reduce the uncertainties originating in the food purchasing process by providing information about the entire food process, from farm to table, in terms of quality and safety[3].

Traceability also known as production resumes, which is mainly used to record production, processing and marketing of agricultural, fishery and livestock products; such as stage, so that consumers have a record of the products are available for queries related problems.

Country of origin labelling has implications for traceability systems in agri-food supply chains. The ability to provide consumers with information on the country of origin requires a basic level of traceability, although does not necessarily imply full traceability throughout the supply chain to the farm[4]. Food traceability systems are an important means to provide food safety and quality information to consumers[6].

Traceability verification framework mainly refers to the organization through a third-party verification to view agricultural presence in the production process; thus, through the establishment of agricultural system, hoping to achieve a number of objectives, such as agricultural information transparency. The ultimate goal is to make consumers eat more safely. Farmers will learn simple system operation, and the information can be uploaded to the traceability of agricultural products traceability system, whereby the production and marketing of agricultural products is done from the shelves of goods to other processes. Consumers can understand the production process through a system of agricultural products, thereby shorten the distance between farmers and consumers.

Research design

System architecture

Our system can be divided into two modules (Fig. 5): the monitoring system and the production data module. Using wireless sensor, the first module monitors the aqua-farm and transmits data whenever required to the persons responsible, enabling them to stay updated on the current state of the farm. The production data module records data on the aquaculture process, from hatching to sale. Through the aquaculture cloud management system, consumers can check to see whether products are in line with food safety regulations.

If downstream companies discover that products are detective, they can track the problem to upstream companies to identify the cause.

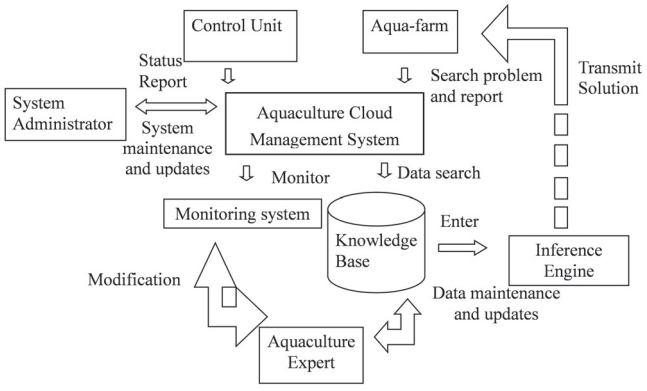

Fig. 5. Aquaculture cloud management system

Monitoring system

Through the control unit, the monitoring system monitors the state of the aqua-farm (such as PH value and oxygen concentration) and transmits this data using a wireless network (Fig. 6). The system also feeds the organisms through an automated feeding system. In the event of an incident or emergency, the control unit automatically activates functions to alert personnel, demonstrating advantages of speed and convenience.

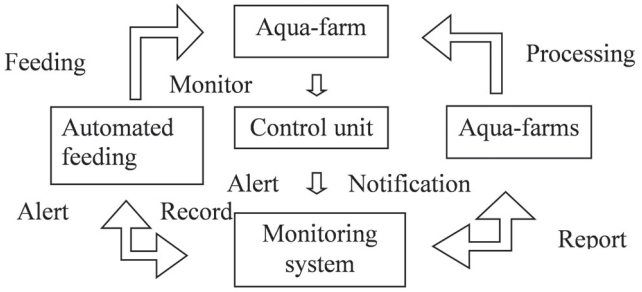

Fig. 6. Monitoring System

3.3 Production data module

The production data module tracks the product from breeding to transport and sale (Fig. 7). The source and destination of relevant products at each phase can be found through the module, allowing consumers to make educated decisions about purchasing products. Should problems, such as outdated or poor quality products arise, downstream companies or consumers can search the system for the product source using the identification tag, and identify the cause of the problem within a short period of time.

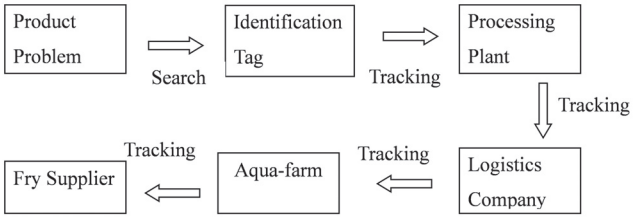

Fig. 7. Tracking product path

Conclusion

Apart from helping aqua-farms conserve resources and improve quality, our aquaculture cloud management system allows consumers to understand the production process and make informed purchasing

decisions. We hope our system will resolve the current lack of information transparency surrounding aquatic products and contribute to strong supply chain relationships, creating greater commercial opportunity and benefit for the aquaculture industry in Taiwan.

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