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Content

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OFDM System and peak to average power ratio reduction methods

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Abstract

The present article deals in a general way with the adverse effects of power peaks in multi-carrier communication systems, specifically, orthogonal frequency division modulation systems, each of the transformation stages is briefly described to generate a multi-carrier signal . In addition, the most common methods for reducing unwanted power peaks are discussed, and it is briefly explained how power peaks are measured using the ratio of maximum and average power. Additionally, the methods of signal predistortion and the simulation of the application of nonlinear predistortion methods in a multi-carrier communication system by orthogonal division of frequencies are explained quickly. Finally, some conclusions about the methods of asymmetric predistortion due to nonlinear transformations of the amplitude of the signal.

OFDM, PAPR, companding, non-linearities, power amplifiers

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Introdution

The current society demands more capacity to exchange information and powerful networks in terms of high speed data transmission and bandwidth capacity. Optical networks are the predominant technology to achieve this objective [1]. Recently, there has been interest in investigating optical communication systems using multicarrier modulation formats, such as orthogonal frequency division multiplexing (OFDM), in their various configurations [2]. OFDM has the necessary characteristics to meet the needs of bandwidth efficiency and high speed data transmission; some of these researches are aimed to reduce the nonlinearities present in some electronic components, such as power amplifiers. These nonlinearities are caused by the presence of high peak power relative to the average power; this phenomenon is measured as Peak to Average Power Ratio (PAPR).

This paper presents in Section II the basic concepts about multicarrier modulation. Section III explains the typical orthogonal frequency division multiplexing system, and its special features when applied to optical communications systems. Section IV gives a briefly review to the optical amplifier features and its characteristics. Section V and VI treat the peak to average power ratio (PAPR), and the most recent methods to reduce this important issue in OFDM systems. Finally, Section VII draws the conclusions of this report.

Multicarrier Modulation

Multicarrier Modulation (MCM) is a transmission scheme that uses several carriers to transmit data generated at the baseband by means of its translation in frequency to the passband of the channel [3]. Fig. 1 shows the MCM basic frequency diagram.

The most common MCM schemes are Frequency Division Multiplexing (FDM) and Orthogonal Frequency Division Multiplexing (OFDM) [4].

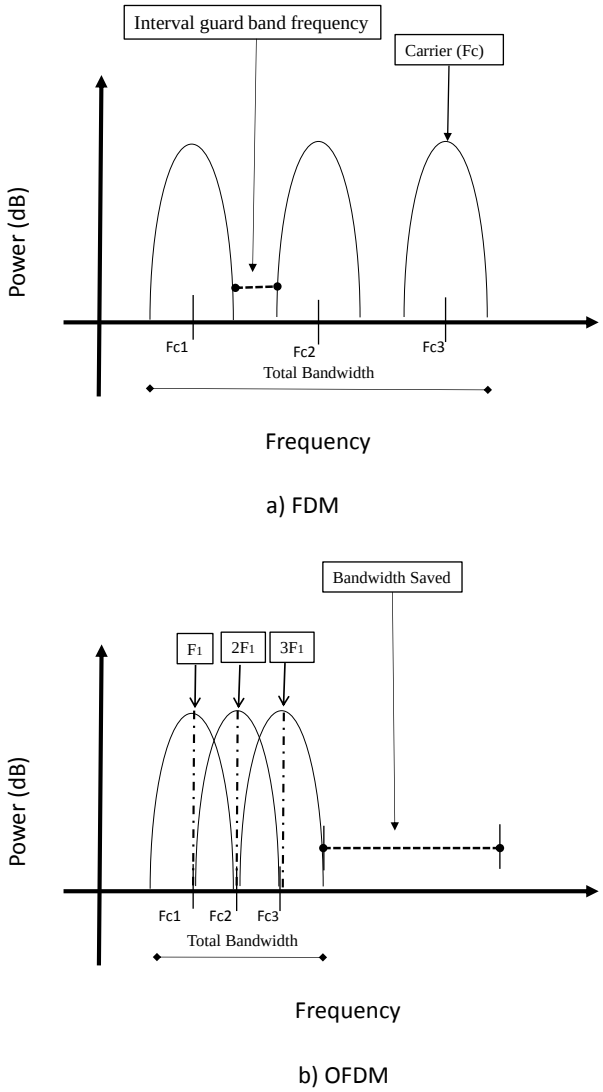
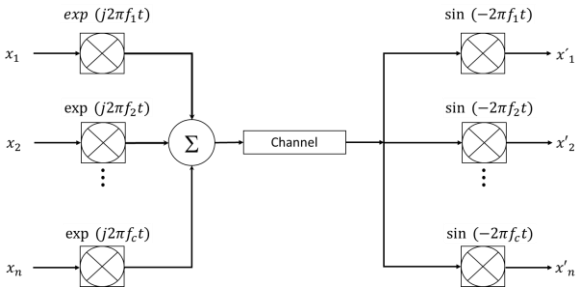


Figure 1 Comparison of power spectrum between a) FDM and b) OFDM.

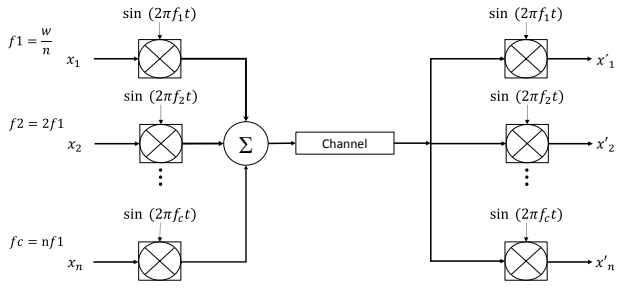
Frequency Division Multiplexing (FDM)

FDM allows to transmit multiple signals in a singular channel to multiple users. FDM assigns to each user a different carrier frequency for transmission.

Fig. 2 illustrates the process to modulate a generic multicarrier FDM signal, where each signal x_n modulates a separate carrier f_c and each carrier is summed to be transmitted over the channel. Every single carrier is generated independently, however, the carrier frequency for each user is chosen so that the transmissions do not overlap in frequency. This results in a significant use of bandwidth as shown in Fig. 1a.



a) FDM



b)OFDM

Figure 2 Multicarrier modulation FDM system basic diagram. a) FDM, b) OFDM.

Equation (1) shows the basic principle of an MCM system, where the multicarriers are added for transmission and must be separated in the receiver before demodulation [5].

$$s(t) = x_1\, sin(2\pi f_1 t) + x_2\, sin(2\pi f_2 t) + \cdots x_n\, sin(2\pi f_c t) \quad (1)$$

where f_1, f_2, … f_c are the carriers frequencies, and x_1, x_2, … x_n are the signals.

Orthogonal Frequency Division Multiplexing (OFDM)

An alternative to improve the FDM scheme is the orthogonal frequency division multiplexing (OFDM). OFDM is a type of MCM and a special case of FDM. The principal advantage of OFDM over FDM is the bandwidth saved, this is possible because the OFDM signal presents orthogonality between subcarriers. This is made thanks to the use of subcarrier frequencies that are multiples of the first frequency f_1 (harmonics), as shown in Fig. 2b. The spectra between subcarriers overlap, but each subcarrier is in the spectral nulls of all other subcarriers [6]. Fig. 1b shows this principle in the frequency domain. A basic diagram of OFDM system is shown in Fig. 1b. Note that the main difference between FDM and OFDM is the way that the carrier frequencies are chosen, as seen in Fig. 2.

The OFDM System

OFDM has been widely deployed in wireless communications and recently studied for optical communications. Some of its main characteristics are the low level of Inter Symbolic Interference (ISI), and the high spectral efficiency compared with other techniques of multicarrier modulation like FDM.

Elements of the OFDM system

Fig. 3 shows a basic block diagram of OFDM system. The first step is to convert the input data stream into a code-word, using coding and interleaving techniques to reduce the Bit Error Rate (BER).

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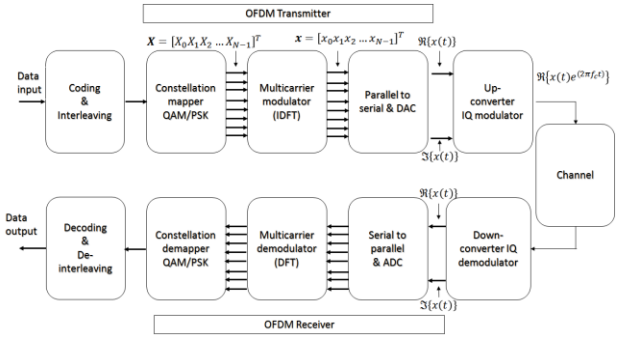

Figure 3 Basic block diagram of an OFDM system.

The second step consists of mapping each of the data words using an M-ary modulation technique like Quadrature Amplitude Modulation QAM or Phase-Shift Keying PSK, this is made at the lowpass equivalent signal level so a complex signal is produced. The output of this functional block is a set of parallel data symbols, as shown in Fig. 4. The data symbols are oversampled introducing a set of null subcarriers. Each output symbol is independently modulated on a separate subcarrier frequency.

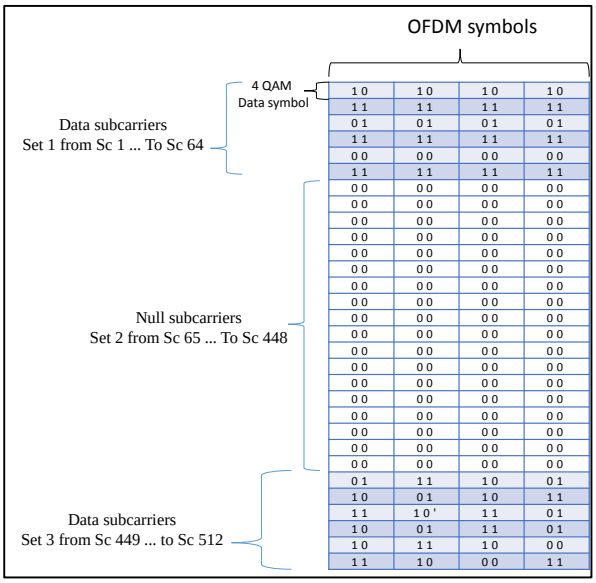

Figure 4 OFDM symbol arrangement before multicarrier modulation

The multicarrier modulator and demodulator in OFDM, whose mathematical expression was presented in the last section, can be implemented by the use of a parallel bank of filters based on the Inverse Discrete Fourier transform (IDFT). This functional block eliminates the necessity of using local oscillators and filters per each signal, as shown in Fig. 1b. The definition of the Inverse Discrete Fourier Transform for the OFDM symbol sample is:

$$x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k \cdot e^{\left(\frac{j2\pi kn}{N}\right)} \; for \; 0 \leq n \leq N-1 \qquad (2)$$

where N is the total quantity of subcarriers, k is the subcarrier number, and X_k is the data carrier in "k" subcarrier.

The input to the IDFT block is the complex vector $\boldsymbol{X} = [X_0 X_1 X_2 \ldots X_{N-1}]^T$, where N is the size of the IDFT, and each of the array elements represents the data to be carried in the corresponding subcarrier. The resulting complex vector in the output of the IDFT is $\boldsymbol{x} = [x_0 x_1 x_2 \ldots x_{N-1}]^T$, as shown in Fig. 3.

OFDM modulation and demodulation based on IDFT/DFT can be performed efficiently by the use of Inverse Fast Fourier Transform (IFFT) and Fast Fourier Transform respectively. This implementation reduces computation complexity.

The complex vector $\boldsymbol{x}$ generated by computing the IFFT is passed through a parallel to serial converter (P/S), and then, to a digital to analog converter (DAC), where the output is the OFDM signal waveform $x(t)$. This analog signal corresponds to the sum of the baseband subcarriers. As said before, the modulation is made at the low pass equivalent signal level so $x(t)$ represents the baseband complex value signal having real $\Re\{x(t)\}$ and imaginary parts $\Im\{x(t)\}$.

$$x(t) = R\{x(t)\} + \Im\{x(t)\} \qquad (3)$$

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Finally, the baseband complex value signal $x(t)$ is up-converted to passband signal $s(t)$ ready to be transmitted. Mathematically, this transformation involves a complex multiplier (mixer) that can be expressed by (4), where the passband signal $s(t)$ is a real-value signal at the center frequency carrier of f_c.

$$\begin{aligned} s(t) = {} & \Re\{x(t)\}\, e^{(2\pi f_c t)} \\ & \Re\{x(t)\}\cos(2\pi f_c t) - \Im\{x(t)\}\sin(2\pi f_c t) \end{aligned} \quad (4)$$

This kind of modulation uses an "In phase (I)" and "In quadrature (Q)" modulator (IQ modulator). IQ data inputs represents the complex value signal, where $I = \Re\{x(t)\}cos(2\pi f_c t)$ is the real part of the signal and $Q = \Im\{x(t)\}sin(2\pi f_c t)$ is the imaginary part of the signal.

The I/Q modulator mixes the I part of the signal with the f_c carrier, and mixes the Q part of the signal with the same carrier at a 90-degree phase offset as shown in Fig. 5.The Q signal is subtracted from the output signal producing the final OFDM signal to be transmitted.

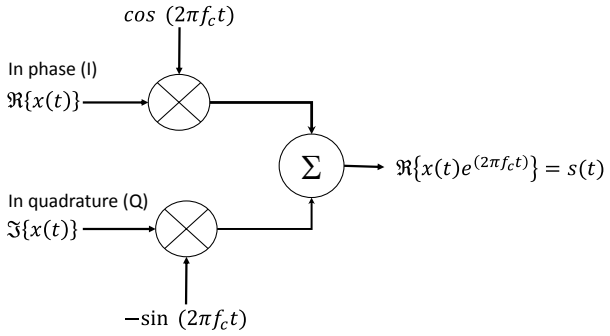

Figure 5 Up-converter IQ Modulator block diagram, and the resulting OFDM signal $s(t)$.

The second part of the OFDM system is the receiver that is shown in Fig. 3. It is composed by the same functional blocks as the transmitter, but doing the inverse actions.

The aim of the receiver is to transform the analog passband signal that comes from the channel to baseband signal using a down-converter IQ demodulator. After this step, the baseband signal is demodulated and converted to serial digital data, which is the nature of the transmitter data input, as shown in Fig. 3.

Application	Name of the Standard
Digital Audio Broadcasting	DAB Eureka 147
Digital television	DVB-T/T2 (terrestrial), DVB-H (handheld), DMB-T/H, DVB-C2 (cable)
Wireless LAN	LAN IEEE 802.11a, IEEE 802.11g, IEEE 802.11n, IEEE 802.11ac, and IEEE 802.11ad
Worldwide Interoperability for Microwave Access	WiMAX (30-40 Gbps)
Asymmetric digital subscriber line	ADSL High speed data communications ADSL (G.dmt/ITUG.992.1)
Long Term Evolution	LTE and LTE Advanced 4G mobile phone standards
Modern narrow and BROADBAND power line communications.	IEEE 1901, ITU-T G.hn standard

Table 1 ofdm standards

Table I shows the different communication standards where OFDM is used. OFDM is present in different areas of communication technology like audio, video, data, smart grid, and it has a promising future in high speed data rate systems [7]. In fact, OFDM has recently been applied to optical communications, in consequence, a diversity of optical OFDM systems have been proposed, like Coherent Optical OFDM (CO-OFDM) for their special modulation scheme.

Peak to Average Power Ratio

A major disadvantage of the OFDM systems is the high peak-to-average power ratio (PAPR) that is inherent in the transmitted signal. Large signal peaks occurs when the signals in the K subcarriers add constructively in phase. Such large signal peaks may saturate the power amplifier at the transmitter and, thus, cause intermodulation distortion in the transmitted signal. Fig. 6 shown the high peaks in an OFDM and the average magnitude.

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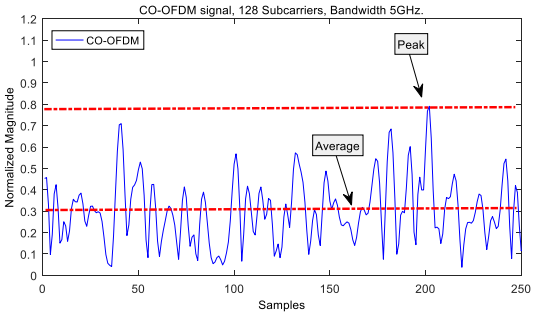

Figure 6 OFDM signal, QAM baseband modulation, 128 subcarriers, 5 GHz, baseband bandwidth

The lowpass equivalent OFDM signal $x(t)$ has a PAPR defined as the ratio between the maximum instantaneous power and its average power, Pav.

$$PAPR[x(t)] = \frac{\underset{0\leq t\leq NT}{max}[x(t)^2]}{P_{av}} \quad (5)$$

where *N* is the number of subcarrier and *T* is the symbol period [12].

Reduction Methods for PAPR

As mentioned earlier, a high PAPR drives into saturation the power amplifier (PA) in an OFDM transmitter producing nonlinearities in the output signal. One solution is to reduce the average power of the signal, but the performance of the amplification is also reduced. The most useful technique is to maintain the PA working with a good performance, high output power, but reducing the power peaks of the signal.

The literature presents many PAPR reduction techniques published since the high PAPR problem was detected. These techniques can be classified in three main categories, as shown in Fig. 12: Signal Distortion techniques, with special emphasis in the companding techniques, which have good results in PAPR reduction with low BER and a low power complexity.

Multiple Signaling and Probabilistic techniques; and Coding techniques, which present a low performance in terms of BER and a high computational complexity.

A. Coding Techniques

As mentioned in Section II, coding is part of the first functional block in OFDM system, the main purpose being data protection and correction. The basic idea in a coding scheme to reduce PAPR is mapping the code word and drop those code words with a high probability to present a high PAPR.

Other coding technique works with phase adjustment, multiplying the code words by a phase adjustment vector, and selecting the code words with the lowest PAPR to be transmitted [8].

B. Multiple Signaling and Probabilistic Techniques

These techniques work in one of two ways. The first one is the selective mapping, which generates multiple permutations of the OFDM signal and transmits the code word with minimum PAPR. The other way is to modify the OFDM signal by introducing phase shifts, adding peak reduction carriers, or changing constellation points. The modification parameters are optimized to minimize PAPR.

a) Selective Mapping: Selective mapping (SLM) is a relatively simple approach to reduce PAPR. It generates a set of sufficiently different OFDM symbols, each of length *N*, all representing the same information as the original OFDM symbol *x*, then it transmits the one with the least PAPR. Information about the selected phase sequence should be transmitted to the receiver as side information to allow the recovery of the original symbol sequence at the receiver, which reduces the data transmission

b) Partial Transmit Sequence: In partial transmit sequence (PTS), an input data block of length *N* is partitioned into a number of disjoint sub-blocks. The IDFT for each of these sub-blocks is computed separately and then weighted by a phase factor. The phase factors are selected in such a way as to minimize the PAPR of the combined signal of all the sub-blocks. The process of selecting the optimum phase factors is usually limited to a finite number of elements to reduce search complexity [9].

C. Signal Distortion Techniques

These techniques introduces a distortion into the transmission signal before the amplification process. In addition, they can be classified in clipping and filtering, peak windowing, and peak cancellation. One of their characteristics is that the peaks are removed from the signal, but the drawback is an increase in the BER. A brief description about the most common signal distortion techniques follows.

a) Clipping and filtering: This method uses a clipper that limits the high peaks of the OFDM signal envelope to a predetermined clipping level (CL) if the signal exceeds that level; otherwise, the clipper passes the signal to the High Power Amplifier without change. This introduces in-band distortion and out-band distortion. Filtering the clipped OFDM signal can preserve the spectral efficiency by eliminating the out-of band distortion and, hence, improving the BER performance, but it can lead to peak power regrowth.

b) Peak windowing: The peak windowing limits such high peaks by multiplying them by a weighting function called a window function. Many window functions can be used in this process as long as they have good spectral properties, and they reduce the distortion as compared with clipping and filtering.

c) Peak cancellation: A peak cancellation waveform is appropriately generated, scaled, shifted and subtracted from the OFDM signal at those segments that exhibit high peaks. Peak cancellation can be carried out after the IFFT block of the OFDM transmitter. While performing the peak cancellation process, care should be taken to not create new peaks.

d) Companding Transforms: Companding transforms are typically applied to speech signals to optimize the required number of bits per sample. OFDM and speech signals behave similarly and these techniques have a relatively low computational complexity as compared to other PAPR reduction techniques. In this case companding complexity is not affected by the number of subcarriers. Companding transforms can be generally classified into four classes: linear symmetrical transform (LST), linear asymmetrical transform (LAST), nonlinear symmetrical transform (NLST), and nonlinear asymmetrical transform (NLAST). Fig. 13 depicts the profiles of these four classes [8]. The NLAST increases the mean power and reduces the peak power, and, consequently, reduces PAPR.

Numerical simulation results

In this section we present numerical simulation result of application of the most used and effectiveness nonlinear companding transforms.

The first nonlinear companding transform is the μ-law. The μ-law belongs to the NLAST. It works compressing large signals and enlarging small ones, with the drawback of increasing the average power of the transmitted signal The μ-law is shown as follows

$$s'_n = sgn(s_n) \cdot \frac{A}{\ln(1+u)} \ln\left(1 + \frac{u}{A}|s_n|\right) \qquad (5)$$

where u is the companding parameter and A is the maximum absolute value of the amplitude signal s_n.

The second one is the NLAST method wich is named as a wang's NLAST.

Another NLAST is presented by Wang et. al. in [10] and it's expressed as a piecewise function. This algorithm proposes to modify the statistics of the amplitude, defined by its Probability Density Function (PDF). The companding function is given by

$$s'_n = \begin{cases} sgn(s_n)\sqrt{\frac{2}{k_1}\left(1-e^{\left(-\frac{|s_n|^2}{\sigma^2}\right)}\right)} & |s_n| \le M \\ sgn(s_n)\frac{1}{k_2}\left((k_2-k_1)c\cdot D+\sqrt{(k_2-k_1)k_1c^2D^2+2k_2\left(1-e^{\left(-\frac{|s_n|^2}{\sigma^2}\right)}\right)}\right) & |s_n| > M \end{cases} \quad (7)$$

where k_1, k_2 and c$(0 < c < 1)$ are the companding parameters, $M = \sigma\left(-\ln(1-(k_1/2)c^2D^2)\right)^{1/2}$ is the inflexión point, , and D $(D > 0)$is the cutoff point.

We used a OFDM transmitter simulator based on Matlab to measure the PAPR reduction per ODFM symbol generated, the OFDM frame is set up with 128 data subcarriers,4 QAM modulation, oversampling factor of 4, 5 GHz of base. Fig. 7 Shown a fraction of data samples in time where Wang compander has more compression level when the high peaks are presents compared with ulaw.

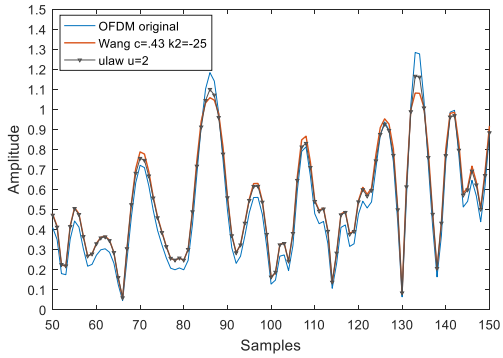

Figure 7 OFDM signal companded by two NLAST, wang and ulaw.

As mentioned before companding methods changes the statistical distribution of the amplitude level of the OFDM signal, Fig. 8 shown the PDF of each companded method, u-law increase power average of the signal, instead of that Wang have a cut off point for high amplitude level.

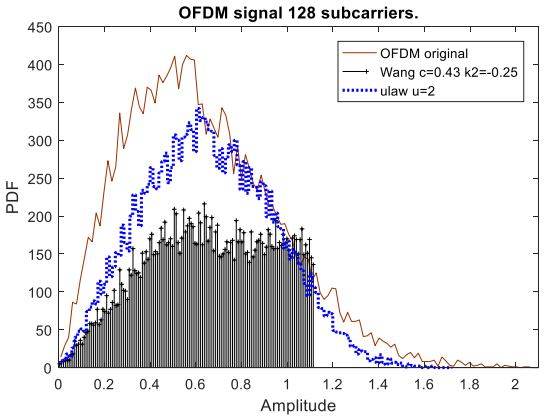

Figure 8 OFDM companded signal PDF. Comparison between ulaw and Wang NLAST.

Finally the PAPR reduction is shown in Fig. 9. As a result each PAPR was calculated per OFDM symbol. In total we have 32 OFDM symbols. The lower PAPR level is obtained by Wang with a PAPR constant value of 4 dB, in contrast ulaw have proportional reduction approximated of 2 dB in each OFDM symbol.

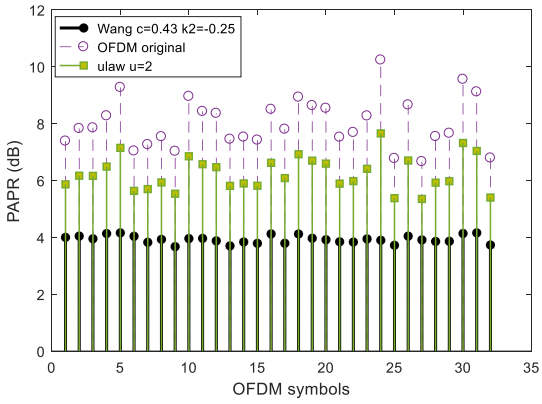

Figure 9.PAPR per OFDM symbol, Wang compander has more PAPR reduction level than ulaw.

Conclusions

OFDM has a promising future in optical communications systems, hence it is attractive to search for novel techniques that increase performance, reduce PAPR, and thus prevent nonlinearities in optical power.Related to PAPR reduction, the Wang nonlinear companding methods exhibit a good performance compared with ulaw. However the NLAST companding methods shows a low computational complexity to be implemented, but little information has been reported in the literature. This open up new possibilities for research in novel techniques based on improving the properties of nonlinear companding techniques. In addition the future perspectives of this work is to implement more companding methods to compare, and increase the simulation to a optical OFDM system taking into account other interaction sichas optical amplifiers and digital to analog converters.

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A Correlation Analysis of 2D-DCT coefficients of face images

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Abstract

In this paper, we present a correlation analysis performed on the coefficients of the discrete cosine transform (DCT) obtained from images of the ORL face database segmented into overlapping blocks. The primary objective of this work was to identify those coefficients that show big variance between images from different persons but, at the same time, keep the most similar behaviour across pictures of the same subject. This project was done in four stages. In stage one, we segmented face images in overlapping blocks. Then, in a second step, the DCT was applied to each of the blocks and the coefficients were stored. In stage three a variance analysis was made to identify the coefficients of higher variation. Finally, we calculated correlations between coefficients to distinguish those that maintain the most similar behaviour for each person. Results and conclusion of this work will be of central relevance in the face recognition research field, for example, to design novel supervised or unsupervised classification algorithms using a smaller number of coefficients than those reported in the literature.

2D-DCT Coefficients, Correlation, Variance

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Introduction

In the last years, face recognition has become a very active research area in the pattern recognition and computer vision field. This topic is of high interest for researchers because of the wide range of possible applications, for example in security, surveillance, commercial purposes, among others. Although big advances have been made in the last decades, there are still some challenges to solve, for example, changes in illumination, partial occlusion or rotation of the images. Moreover, the need to develop real time recognition systems require the design of fast algorithms.

An essential step in a face recognition system is feature extraction. Features are the characteristics that the face recognition system will use to discriminate across faces. Features can be extracted using many techniques, but in general, we can distinguish two approaches: geometric and appearance based. In the geometric approach points, lines, and curves are used to extract features. While, in the second one, pixel values and transformations can be used to select them.

After extracting the features, they must be selected. The problem of selecting features is a global optimisation problem that looks to reduce the number of features, removes irrelevant, noisy and redundant data. In literature, we can find many techniques that have been applied to accomplish this task. Among the most common we can find Principal Component Analysis (Song, Guo & Mei, 2010), Linear Discriminant Analysis (Guyon & Elisseeff, 2003) and Genetic Algorithms (Harandi et al., 2004). In the last decades, techniques as Particle Swarm Optimization (Ramadan & Abdel-Kader, 2009)(Farag, Elghazaly & Hefny, 2016) and Discriminative Power Analysis (Dabbaghchian and Ghaemmaghami, 2010) has also been used.

Another technique widely used to extract features from face images is the Two-dimensional Discrete Cosine Transform (2D-DCT). The success of this technique to extract features is principally due to its capacity to compress data in a small set of coefficients and therefore perform data dimensionality reduction. However, not all the coefficients of this transformation have the same power of discrimination. Furthermore, opposite to what we may think, having a big number of coefficients does not guarantee better recognition results. In fact, it could introduce redundant information reduce the efficiency of the system and increase the computation time (Swets & Weng, 1996). For these reasons, it is recommendable to accomplish a mathematical analysis to select the most appropriate coefficients before training a face recognition classifier.

In this work, we present a correlation analysis applied to coefficients of the 2D-DCT obtained from face images segmented into overlapping blocks. The main objective of this work was to identify coefficients that keep the same behaviour across images of the same person and notable differences for distinct subjects in the database. In other words, we looked for coefficients with large variation across the classes and big correlation within the classes. This investigation was carried out using the ORL face dataset. Our main contribution is the identification of the coefficients that maintain the most similar behaviour across the images of the same person of this data set. This information will be useful to develop and apply supervised techniques to perform face recognition.

The investigation was carried out using the freely available ORL face dataset. The database has ten gray-level images of 40 different persons. Each image has 112 pixels of height (H) and 92 pixels in width (W).

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Pictures were captured under controlled illumination conditions. However, including small variations in facial expression and orientation.

The content of this article is organized as follows. Section II is a brief review of related works. Section III describes the methodology. A theoretical framework can be found in section IV. Results are presented in Section V. Finally, in section VI we make our conclusions.

Related Work

In the field of face recognition, different approaches making use of 2D-DCT have been reported in the literature. In the early work of Nefian & Hayes (1998), face images were segmented into overlapping blocks and the 2D-DCT was applied to each block. Then, coefficients into a 3x13 window of the low frequencies were extracted and used as features to train Hidden Markov Models (HMM) and perform face recognition. Authors chose this window size because the major amount of information is concentred in these coefficients.

Hafed & Levine (2001) presented a face recognition system using the first 64 coefficients (a subset of 8x8) of the low-mid frequency 2D-DCT coefficients. The size of this subset was chosen such that it could sufficiently represent a face. Nevertheless, authors claimed that a small number of them could also give good results. Face recognition in this algorithm is accomplished comparing the feature vector of the input image to the feature vector of the dataset using the Euclidean distance nearest neighbour classifier.

In another method proposed to achieve face recognition, a Nearest Neighbour Discriminant Analysis (NNDA) applied to 2D-DCT coefficients was presented by Tyagi & Khanna (2012). First, authors applied the transformation to the whole image to extract features.

Then, they extracted a 16x16 window of low-frequency coefficients were used to train an algorithm using NNDA.

Dabbaghchian & Ghaemmaghami (2010) reported a method to select the coefficients that improve the recognition rate. They named this method Discriminative Power Analysis (DPA) and it is based on the idea of looking for those coefficients that show small variation inside classes and large variation inside classes of a de terminated dataset. They mention that the main difference of a DPA respect to techniques such as Principal Component Analysis (PCA) and Linear Discriminative Analysis (LDA) is that DPA keeps the original domain of the data.

Most recently, Chen et al. (2016), proposed a new face recognition method. This method uses histogram-based features in spatial and frequency domains. First, authors divide the face image into regions and then build a feature vector for every resulting area using a histogram of the low-frequency coefficients of the 2D-DCT, as well as Local Binary Pattern (LBP) histogram in the spatial domain. The DCT coefficients used in this work were obtained with a mask of size 4x4. Hence, they used only the first 16 frequency coefficients obtaining good results.

As can be verified in this brief review of the literature, there are many methods to select the 2D-DCT coefficients to be used as features for a classification task. While some authors use a feature selection technique, other just select the coefficients in a zigzag manner or extract a rectangular window throughout a mask. (Dabbaghchian and Ghaemmaghami, 2010).

Theoretical framework

Two-dimensional Discrete Cosine Transform

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If f(x,y) is an image of size MxN, the 2D-DCT of the image f(x,y), f(u,v), can be computed as defined in the equations 1 and 2.

$$F(u,v)=\frac{1}{\sqrt{MN}}\alpha(u)\alpha(v)\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}f(x,y)\times\cos\left(\frac{(2x+1)u\pi}{2M}\right)\times\cos\left(\frac{(2y+1)v\pi}{2N}\right)\quad u=0,1,\ldots,M,\quad v=0,1,\ldots,N \tag{1}$$

Where:

$$\alpha(\omega)=\begin{cases}\frac{1}{\sqrt{2}} & \omega=0\\ 1 & \text{otherwise}\end{cases} \tag{2}$$

Figure 1 is an example of a gray-level image and its 2D-DCT.

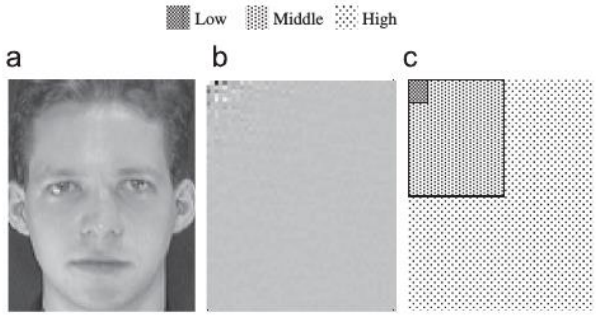

Figure 1 a) A typical face image; b) its 2D-DCT transformed image c)typical division of the coefficients into low, middle and high frequencies. (Dabbaghchian et. al, 2012)

Correlation

Correlation is a statistical technique that can show whether and how strongly pairs of variables are related. It is also used to determine how similar are two variables. There are several different techniques to calculate correlation, for instance, Pearson, Spearman, Kendall, product-momentum correlation, etc. In this work, we used the simple correlation function *corr* provided by octave software. If each row of **X** and **Y** is an observation and each column is a variable, then the (i,j)-th entry of ρ is given by the equation 3.

$$\rho(\boldsymbol{X},\boldsymbol{Y})=\frac{cov(\boldsymbol{X},\boldsymbol{Y})}{std(\boldsymbol{X})*std(\boldsymbol{Y})} \tag{3}$$

Where "*cov"* stands for covariance and "*std"* for standard deviation.

The result of the correlation is named "correlation coefficient" and it is commonly denoted by "ρ". The range of possible values of the correlation is from -1 to 1. A value near to -1 or 1 denotes high related variables, while a value close to 0 indicates poor or no linear relation among them.

Methodology

This project was done in four stages. In stage one, we segmented face images in overlapping blocks. Then, in a second step, the 2D-DCT was applied to each of the blocks and the coefficients were stored. In stage three a variance analysis was made to identify the coefficients of higher variation. Finally, in the last stage, we calculated correlations between coefficients to distinguish those that maintain the most similar behaviour for each person.

Coefficient extraction

To extract the coefficients, we used the methodology reported by Nefian & Hayes (1998). In this method, blocks of size LxW pixels and overlap of P lines were extracted in a top to bottom direction, see **Figure 2**.

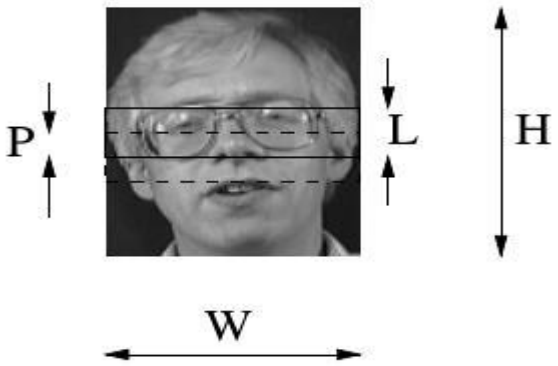

Figure 2 Block extraction method as explained by Nefian & Hayes (1998).

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The total number of blocks *Nb* to extract in an image of *L*x*W* size and *P* overlapping lines can be calculated by the equation 4.

$$N_b = \frac{H-L}{L-P} + 1 \quad (4)$$

After extracting a block, the 2D-DCT transform was applied to it, and the coefficients were stored. The resulting 2D-DCT matrix of the blocks had the same size as the original block, that is, LxW pixels. With the objective to handle the information easier, the coefficients were rearranged in a single vector by concatenating all rows in a single row vector.

Nefian & Hayes (1998) claimed that best results in their method were obtained with L = 10 and P = 9, so we decided to use the same parameter values. With these parameters and the size of ORL face images, equation 4 can be used to determine *Nb*=103 blocks to extract. Moreover, authors suggested the vast amount of information of the 2D-DCT is concentrated in a window of 3x13 coefficients in the lowest frequencies range. Hence we limited our study to this window. In this way, the output of this stage was a four-dimensional array **C** of size [Np x Ni x Nb x Nc].

Where:

N_p = Number of persons in training set = 40.

N_i = Number of images to use as training = 10.

N_b = Number of blocks = 103.

N_c = Number of coefficients= 39.

Variance Analysis

The objective of this stage was to determine the coefficients that present more variation in the whole database. This was done calculating the variance (σ^2) of each coefficient for the total data, that is, including all people.

Results can be consulted in Figure 3. As can be noted, higher variance appears in the low-frequency coefficients. However, special attention deserves coefficients 1 and 3.

The variance for each person was also calculated. Again, as can be verified in Figure 4, the coefficients showing the greatest variation are 1 and 3.

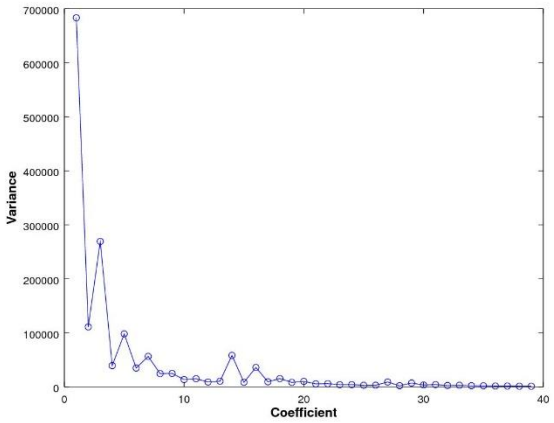

Figure 3 Coefficient variance for the total database.

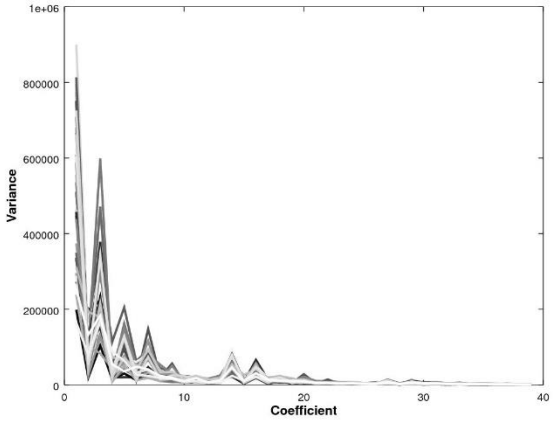

Figure 4 Coefficient variance per person.

Correlation

In this stage, a correlation was applied to the coefficients with the aim to detect those that maintain the most similar characteristics across the whole set of images of the same person.

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The first image of each person was taken as the control curve. Then the correlation between each coefficient of this image and its correspondent coefficient of the subsequent 9 images were calculated. Hence the total number of correlation computed was 40 persons x 9 subsequent images x 39 coefficients = 14040 correlation coefficients computed. A correlation near 1 indicates a good that the coefficient kept almost the same behaviour across all the images of the subject. A low correlation value indicates big changes in the path and behaviour of that coefficients. Figure 5 shows the correlation of the coefficients for the first 5 persons of the database. We only present results for the first five subjects to keep graph clarity. However, the rest of curves are similar looking.

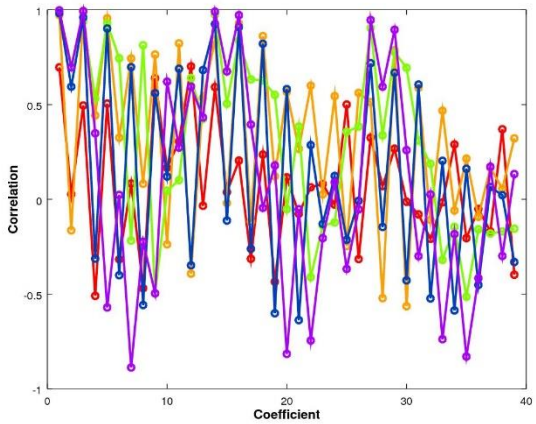

Figure 5 Coefficient correlation for the first five persons in the database.

Results

As suggested in **Figure 5** the coefficients with the highest correlation are 1, 3, and 7. However, it is not true in all the cases. For this reason, in Figure 6 we present a histogram showing the percentage of times that each coefficient appeared ranked as the most correlated.

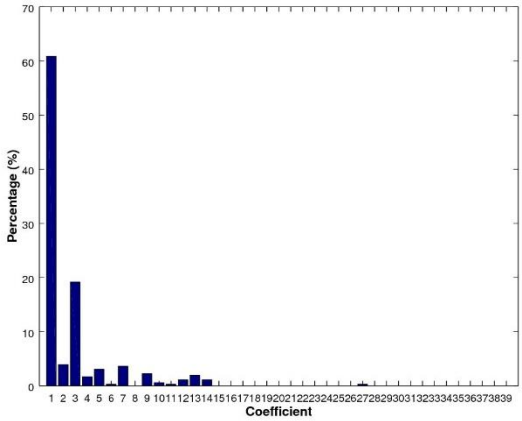

Figure 6 Percentage of times the given coefficient was the most correlated.

As can be verified in Figure 6 the coefficient number 1 appeared 61 % of times as the most correlated. It means that of the total of 360 tests (40 persons * 9 images), the coefficient 1 was the most correlated with itself at least 219 times. The second most correlated coefficient is the third.

Figure 7 shows the percentage of times that the coefficient appeared in the top three of most correlated coefficients. According to the figure, coefficients 1, 3, 5, 7 and 14 are the most frequent in this top three. In fact, all they together sum a total of around 80 %.

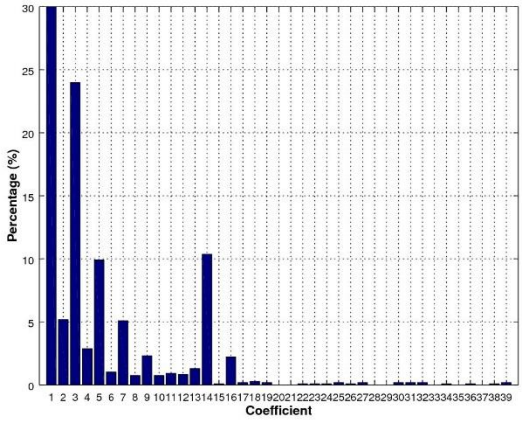

Figure 7 Percentage of times that the specific coefficient appeared in the top three most correlated.

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In Figure 8, we present a scatter plot of the coefficients 2 and 4 for the ten images of the subject 4 in the database, one colour for each image. Each one of the points corresponds to a different block. In total there are 103 points in the plot for each image. As we can see the curves are not similar, in other words, are poorly correlated. In contrast, Figure 9 presents a scatter plot of the same person but this time using coefficients 1 and 3. In agreement with our results, the curves show more similitudes and hence are better correlated.

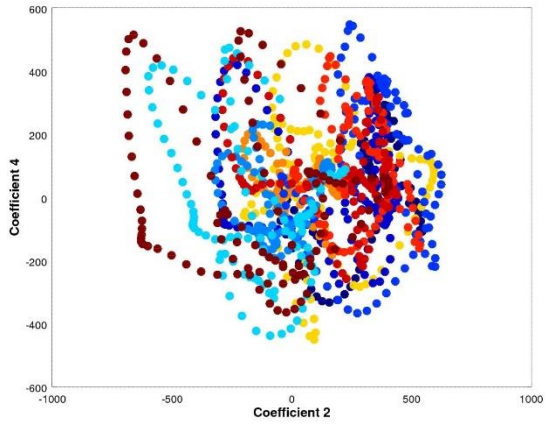

Figure 8 Scatter plot of the coefficients 2 and 4 for the subject 4 in the ORL database, one color for each image. Curves show low correlation.

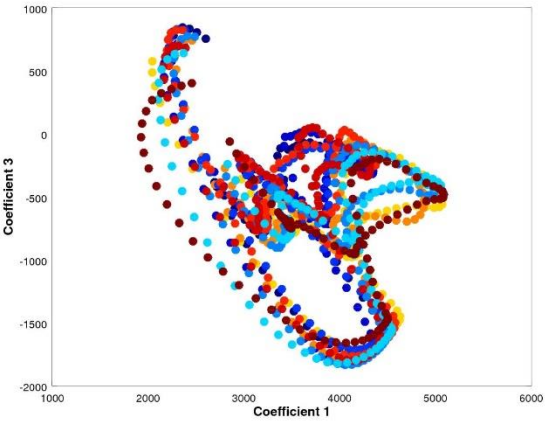

Figure 9 Scatter plot of the Coefficients 1 and 3 for the subject 4 in the ORL database, one colour for each image. Curves show high correlation.

Conclusions

In this article, we performed a correlation analysis to identify those coefficients of the 2D-DCT that keeps most similarities in face images of the ORL Face database. The study shows that coefficients 1, 3, 5, 7 and 14 are the most correlated and hence they are good options to be used to train supervised or unsupervised face recognition algorithms. Also, the mentioned coefficients presented a great level of variance across subjects and therefore have potential to discriminate.

Nevertheless, it is important to clarify that the method here presented is database dependent and therefore, this procedure must be repeated for each one.

Future Work

As future work, we plan to use the results of this investigation to train Discrete Hidden Markov Models to recognize faces using a small number of coefficients.

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Computer system to share first stage teaching strategies

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Abstract

The development of a web platform, aimed at teachers, is presented, in which teaching strategies can be recorded, with sections such as name, description, recommendation of subject and level of education, as well as examples and the perception of its application. It is desired to create a community of registered teachers who interact to share their positive and negative experiences and be this platform the means of communication, to strengthen the resources of higher education teachers. We present the relational diagram of the database already constructed with the attributes congruent to the objective of the system. It shows the first interface of the system in which it is observed what will be the search criteria and the url in which it is being developed in this phase The project involves teachers and students from the Universidad Tecnológica del Valle de Toluca.

Software development, didactic strategies

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Introduction

Good education is undoubtedly a factor of change and improvement of society. Our country Mexico is thirsty for positive changes that enhance the values of men and women who are capable of moving Mexico in the right direction in the social, technological and scientific fields. Higher education plays a fundamental role in the training of professionals with competences relevant to the current time. Competences that break bad habits, that build a society more prepared, more just and more united.

For the development of competences in higher level students, well-prepared teachers are required who, in addition to using the instruction techniques they received in their time, dare to change, complementing their teaching practice with new strategies, recognizing that today's students they do not have the same characteristics as the young people of years ago, taking into account that the means and resources have been expanded and should be exploited.

Justification

The platform that is being developed, is intended to be a space for consulting teaching strategies and also to share the experiences of teachers on the treatment of various topics, to strengthen and expand the resources of teachers. It is expected that this platform will be a support to improve the competences of the students and increase the graduation rate in higher education.

Problem

With the growth of coverage at a higher level, and changes in educational models, student attention has become relevant, seeking to acquire the professional skills of the graduate profile of each career, recognizing that each student is a unique person, with different learning skills, and that teachers have the commitment to seek different teaching strategies to increase the learning of their students, in order to achieve competent graduates in the social, scientific and technological fields.

So the institutions make an important effort to train their teachers with courses, which are valuable, however it is not easy to follow up on the application within the classroom, in addition to the existence of teacher rotation, with which you have to start again the training process. In teaching plants there are professionals with extensive experience who include within their class sessions, innovative, effective and even fun strategies, which includes more ways of student learning. However, in the best of cases these teachers get to comment informally to some colleagues their teaching strategies. On the other hand theoretically they are documented, many strategies with examples of application, in books, in Internet pages and in magazines of educational subjects, likewise in congress forums or in general in face-to-face or online conferences.

This project detects as a problem that the majority of teachers do not have a wide range of teaching strategies to apply in the classroom.

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Hypotesis

By implementing a platform that contains the description of the teaching strategies recognized in the literature, the option that each teacher can enrich their experience with each of them, or upload a new strategy, with suggestions for its application and the results you perceived. It would help the entire teaching staff, to increase their teaching resources, which is expected to have a direct impact on student learning and graduation rates..

Objectives

General objective

Develop a computer platform in which the description of teaching strategies can be consulted, and achieve a teaching community that enriches the content with experiences and new techniques, including videos of the associated teachers, in order to strengthen the teaching skills of the teachers, hoping that it directly impacts student learning.

Specific objectives

- Study and describe the teaching strategies suggested in the literature
- Design of the components that the platform should contain
- Develop the computer platform
- Pilot test. Conduct a teachers' association of the Technological Unversity of the Valley of Toluca for the use of the platform
- Make improvements based on the result of the pilot test
- Extend the invitation to teachers from other Universities.

Theoretical framework

In recent years, Mexico has expanded coverage of the upper and upper secondary level, expanding the infrastructure of universities and building new schools. In higher education, it is worth noting the creation of Technological Institutes, Technological Universities and Polytechnic Universities, gradually increasing the infrastructure of each of them. The subsystem of Technological Universities has been in existence for 25 years, started in 1991. It is currently constituted by 115 schools, serves 245 thousand students, with half a million graduates (Mayer). Regarding the Polytechnic Universities, it is a subsystem that started in 2002, there are already 50 schools, there are also 50 Technological Institutes, in addition to expansion of the offer in Autonomous Universities and Private Campus. In the great majority, the teaching staff has an educational profile at the undergraduate level, or postgraduate, in the various scientific, social and technological areas, not being an essential requirement to have studies in pedagogy, didactic strategies certifications, or similar. The present is a project that pays to the improvement of didactic strategies in higher level teachers.

Research Methodology

A classical methodology is used for technological research (Espejel, 2006), where the procedural level has six stages:

1. Problem Statement
2. Methodological approach directed to the methodological blocks: analysis, synthesis, praxis and synthesis)
3. Protocol design
4. Practical execution that consists of carrying out the actions of the protocol

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5. Summary of the results

6. Integration of the final report

Type of Research

Technological research has as a central objective the innovation or invention of tools, devices and mechanisms to facilitate human work (Espejel, 2006). Therefore, this research is identified as technological since it consists of the development of a platform that facilitates learning and the possibility of sharing various teaching strategies.

Theoretical Methods

The method used to materialize the objective is described in Table 1 in which is the series of steps in each methodological block.

Methodological block	Steps
Analysis	• Study of teaching strategies
Synthesis	• Search for similar web pages and describe their characteristics
Praxis	• Classification of strategies
Synthesis	• Determine the design of the platform

Table 1 Method classified by methodological block

Software Development Methodology

For the development of the platform, the Rational Unified Process (RUP) methodology is used, which identifies four phases: Start, development, and closure or transition. It is a dynamic, iterative methodology that allows the development of software accompanied by system tests and consultations with end users to verify that they meet the requirements (Chacón).

Results

The platform will have the option of registering teaching strategies, in each one you can upload an image, description, the subject (s) and educational level in which it is recommended, example (s) of use and general comments. You will also have the option to register teachers, from which general personal information and your teaching experience will be requested.

The database is already developed, in figure 1 the relational diagram is shown. According to the attributes of each table, the work of recording the different teaching strategies and the teachers is simplified, allowing in the graphic web interface to appreciate in a simple way the different teaching techniques, modifying the content for its update and expanding the quantity of described strategies.

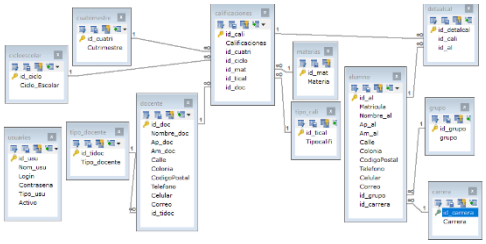

Figure 1 Relational diagram of the database

The system is being developed with the collaboration of students of the career of Advanced University Technician of Information Technology and Communication of the Technological University of Valle de Toluca. Figure 2 shows the interface of the system under development, the url is http://www.evolution-org.online/ for online access. The system will allow searches by name of strategy, topic, or educational level.

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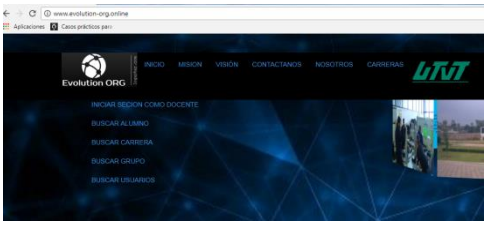

Figura 2 Interfaz del sistema

Conclusions

The platform has the potential to be a valuable tool for the choice of teaching strategies for teachers to cover specific topics, on the internet there is unlimited information on strategies, however, the vision of this system is that in addition to information it includes an efficient means of communication between teachers, no doubt your comments and recommendations are those that enrriqucerán developed tool.

Once the database has been created, the initial strategies that feed the platform have been chosen, the system has been started. The software development must be completed, start with a pilot group of teachers and then be able to include teachers from different careers and universities.

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Remote tracking system for vending machines via WiFi to mobile device

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Abstract

The proposal was developed by a team of students from the Fidel Velázquez Technological University. We focus on designing a system that allows remote monitoring of the operation of vending machines, be they electronic or digital. We focus on this type of machines, since the market for these has increased significantly in the last 5 years, and it is becoming much more sophisticated every day. The fact that a machine stops its operation due to some technical failure, or, fill the so-called "purses", or exhaust your product, means an economic loss for the companies. This economic loss is multiplied if it is known beforehand that rents in shopping centers are very expensive. Therefore, a system that provides remote monitoring and offers information to the administrator or operator of said machines would be a significant competitive advantage.

Virtual Reality, Virtual World, Virtual Museum, Mexican Cinema, Stages of Cinema

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Introduction

The developments within the so-called Information Technologies (ICTs) have gained special importance due to their integrating characteristic for all types of industry, or, of services or within the trade. For some years now, the pure software development model was abandoned, whose purpose was to order only industrial or commercial operations and offer information about the status of operations and indicators.

It is no longer enough for a program to order operations and send information on behavioral indicators. It has become indispensable to integrate digital communication technologies as well as mobile devices so that a system is competitive in the market.

With the appearance of the first smart mobile devices or Smart phones, as well as the development of APPS, a career began that has not stopped designing applications of all kinds. However, until the recent appearance of the so-called Internet of Things, as well as the Internet of Everything, operations, indicators, strategies, logistics, maintenance, etc. will be converted into generic actions of the systems under development.

The cohesion of operations means to be more competitive in the market, much more efficient, and above all, much more flexible to enter new developments of its own, which in the case of Vending Machines is one of its characteristics sine qua non, or rather , the vending machine while having more innovative technological components, will be much more competitive in the market since its life time is very short and it does not exceed 3 years.

It is important to mention that the exponential growth that this type of machine is having is due to the liquidity of its operations, as well as to the profitability itself.

With our development, this profitability could be further improved by ensuring much better profits to entrepreneurs in this field.

In the same way, we can say that not all developments have been built on WiFi platforms, some of them took parallel routes as SMS. However, given that 90% of the mentioned machines, which is our target market, are located in commercial plazas, where it is easy to think that they have Wi Fi coverage, that is why it was decided to develop it on the Android platform, in response to the location of our market

Therefore, the proposal presented is based on a reliable technological infrastructure that allows us to prop up the improvement in profits, reducing costs and increasing sales times, while reducing the error ranges in the service of the same.

Due to the above, our multidisciplinary team, made up of students from the 5th and 6th semesters of the Fidel Velázquez Technological University, both from the Administration, Accounting and Systems career, has allowed us to detect some limitations in the Vending Machines market. both electronic and digital, even with very advanced technological components.

The problem to solve

According to studies carried out in the field in a random way in different commercial places of both CDMX and Edomex, we were able to determine the potential that vending machines have in the Mexican market. Some of them are services, others are entertainment, and some other consumer products.

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All of them, as mentioned, electronic and digital machines, have problems of daily monitoring in their operation, that is, in the case of a strike, this is unknown until the operator visits the machine, or the Mall reports such stoppage, while the machine stops selling and rents continue to run. In the same way, this unemployment can be due to the filling of the purses or exhaustion of product, which can be reported with our system, as well as the daily advance of said machine.

Taking as a background we have divided our article into 5 sections

1. Our proposal
2. Hypothesis
3. The development
4. System Software
5. Conclusions

Our proposal

Currently in Mexico is not known of any device that allows the monitoring of Vending Machines in real time, although they are in the European market especially in Spain, as well as in Japan, which are world leaders in the design of vending machines all types. Therefore, we will try to develop a prototype that would be an independent system to the operation of the machine, that follows up on its operation, either in the entry of coins, in the inventory of the product in the case of having it, or of some technical stoppage, either by filling up purses, or, due to some mechanical or electronic difficulty, transmitted all this to a mobile device.

Initially the national market would be sought, or, if possible in the international or export.

Said device would be incorporated inside the machines, and this would communicate remotely with a mobile device, either an operator or an administrator.

Said technology would allow permanent monitoring of the operation of said machines, being able to observe their progress, some technical breakdown due to breakdown or failure by operation, as well as follow up the inventory within the machines, either of product or of coins.

The present development would allow the owner, administrator, or company to reduce downtime, increase sales for this reason, make maintenance routes more efficient, avoid unnecessary visits to machines, and give corrective maintenance more quickly.

All this would be done on an Android platform, remotely via Wi-Fi to a mobile device.

To make the prototype Arduino component will be used, as well as open software in order to avoid licensing costs that in this case would be unnecessary.

Hypotesis

Our hypothesis is based on the fact that the Schiller equivalent of a Digital Machine producing plastic articles, or mechanical metal, there can be a device that tracks the operation of a vending machine, for obvious reasons this has to be electronic or digital and not mechanical. This can be done through a network of sensors integrated in a device that reports progress, product inventory, currency inventory, as well as a technical stoppage. With this, the companies that operate or sell this type of machines, whether imported or domestic, will have a device that will help them reduce costs and organize maintenance logistics.

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Development

The members of the working group explored some alternatives to evaluate which was the most feasible to incorporate it into the functionalities required by the proposed device. The platforms, software, licenses and components were weighed. Therefore, it was decided that it would have to be in Android Platform, to facilitate its incorporation to most mobile devices. Also, Arduino components were proposed, since their software is completely open and their licenses are free, and with that they will be subject to a reduced budget for our prototype. In the same way, the design of a Domi was initially proposed, in order to observe its functionality and how that technology would behave, this was developed with recycled material.

Once this was done, we proceeded to the acquisition of the components and the development of the functional prototype.

This device, according to what is consulted with experts, is feasible to design it, and it is up to the team to develop the alternatives to solve the proposed approaches for the device.

System Software

For the purpose of WiFi-GPS communication, the Java language was used, which due to its characteristics is a safe, object-oriented language, that is, it allows the reuse of software components, as in our case, of neutral architecture.

Java was chosen because it is a very flexible platform, easy to understand for young people, since it can inherit functionality, adding new features without altering the initial code. At the same time, it is multiplatform which allows us to incorporate the existing system without altering the codes of this.

Finally, the JAVA updates allow to expand the system if necessary or desired by the same team, or other students who wish to incorporate new functionalities.

Conclusions

The development is focused in the first instance to complement a technology whose primary objective is to provide products and services with great promptness, since many people seek quick consumption due to its great activity, or to satisfy a divertimento. In the same way, the proposed complementary development will improve the image that vending machines often "steal our coins", since the service will improve, will be much faster and the times of unemployment will be reduced.

It is for this reason that the first major objective of the development is to improve the efficiency in the market of the aforementioned machines, generate greater revenues for our customers, as well as provide a better service to the public user.

Reduce travel to verify the machines and thereby reduce the polluting gases emitted by long journeys.

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Website and Mobile Application on Land Use Control through the Interactive Map of the Northern Region of the State of Guerrero for INIFAP

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Abstract

A website was created that has user and administrator sections which will generate fertilization recommendations for corn producers located in the municipalities of the Northern Region of Guerrero state. The source of information was provided by the National Institute of Forestry, Livestock and Agricultural Research (INIFAP initials in Spanish), Experimental Field in Iguala. This source emanates from an agricultural census which is a printed document which describes data such as: land owner's name, municipality, town, slope, length, latitude, crop type, source and quantity in kilograms of fertilizer based on the type of PH of the soil: if it is less than 7.5 it will be phosphonitrate and if it is higher than 7.5 it will be ammonium sulphate with its respective source of phosphorus (DAP), from each corn producer in every municipality and town belonging to the Northern region of Guerrero through an interactive map. A mobile application was also carried out which will show information about the INIFAP, and will also provide specific data on the corn sowing plots sampled in each municipality of the Northern Region of the State of Guerrero, such as: predominant climate, agricultural areas, soil types and researchers in INIFAP.

PH, DAP, INIFAP

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1. Introduction

This work is based on the project of professional practice made by three students of the educational program of Engineering in Information Technologies at the Universidad Tecnológica de la Región Norte de Guerrero, the document they presented is a report of those practices that helped them obtain a bachelor degree in the program.

This report was later restructured as a thesis as part of the research project carried out at the National Institute of Forestry, Livestock and Agricultural Research of the State of Guerrero, to obtain the fertilizer treatment called technological package of fertilization of the land of sow for corn producers in the Northern Region of Guerrero through the application of a chemical formula located in three tables attached to this work.

1.1 Justification

INIFAP has an agricultural census which has information on the sowing lands which belong to corn producers from different agricultural areas in the State of Guerrero. These lands are both rainfed and irrigated farming. The construction of the technological fertilization package is done manually searching the information in a printed document, a process that is tedious, whenever it is required to calculate such technological package.

Therefore it is necessary to develop and implement a website and a mobile application for the control of land use through an interactive map which in a first phase will only contemplate the Northern region of Guerrero, and obtain the construction of the technological package of fertilization depending on the agricultural area, thus allowing faster decision making according to the criteria required such as: soil PH, soil type, number of hectares, type of fertilization to be used, among other data.

1.2 Problem

INIFAP is an Institution of scientific and technological excellence with leadership and national and international recognition for its capacity to respond to the demands of knowledge and technological innovations for the benefit of agriculture, livestock and society in general [2]. It is focused on the development of different projects for the improvement and crop fields by carrying out records of PH of the soil, total area of the land to be planted and the total of fertilizer to be used based on an agricultural census of land use on the sowing lands specifically; corn.

Because of the conditions of each crop field are very diverse, some criteria is applied to build the technological package of fertilization. Such information is found in a printed document and only has some samples of the crop fields from corn producers in each municipality and town from the State of Guerrero.

In order to calculate the fertilization treatment, it is necessary to review the agricultural census and, depending on the information, a chemical formula is applied (see the section on annexes for the fertilization section on tables 2, 3 and 4) where the elements that will serve to determine the amount of fertilizer will be used are found and according to the degree of acidity in the PH of the soil the type of fertilizar to be used will be determined.

All this is done manually every time it is required which makes the treatment process tedious and slow; thus creating a bad effect over operability and decision making to know the quantity in kilograms and the type of fertilizer for every specific sowing land.

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1.3 Hypothesis

With the construction of the technological package of fertilization website and mobile application, it will be possible to obtain the source and the exact dose of fertilizer to be applied in the crop lands belonging to corn producers located in the Northern region of the State of Guerrero.

1.4 Objetives

1.4.1 General Objective

To develop and implement a website and a mobile application on land use control through the interactive map of the Northern Region of the State of Guerrero, with the purpose of informing the producers the source and dose of fertilizer to apply in their lands of corn sowing.

1.4.2 Specific Objetives

- To construct the database with the name of inifapbd that includes the tables, such as: Users, Identification, PhysicalFeatures, ChemicalStructure, SoilUse, Crops, States, Municipalities and Localities, through the MySQL database manager.
- To design web site graphical interfaces for user interaction such as web forms through Dreamweaver and Sublime Text 3.
- To build user, search, delete and update modules.
- To deploy security level through User and Adminstrator roles.
- To use programming languages such as: PHP, JavaScript, HTML, Apache Córdoba, Android SDK and IONIC.
- To generate information over the source and dose fertilizer for sowing land belonging to each municipality and town in the Northern region of Guerrero.
- To generate a fertilization report for corn producers in the Northern region of the State of Guerrero through a PDF document for consultation and printing.
- To build the appropriate mobile application for the website to provide information to producers in the Northern region of the State of Guerrero.

3.1 Type of Research

To contextualize our prototypes of website and mobile application, it is located in the area of applied research as a technology transference since it solves the problem of the amount of fertilizer to be occupied in the field of sowing by corn producers in the Northern Region Of Guerrero, starting from the degree of acidity of the soil PH, using a chemical formula that is found on the three tables that are in the category of annexes in the section of fertilization of each table regardless the level of productivity whether it is high, medium, or low (See Annexes, Tables 2, 3 and 4), and contains the elements that allow calculating the amount of fertilizer in kilograms and the type of fertilizer to be applied to the land.

3.2 Theorical Methods

In order to carry out the present research project between the INIFAP and the Universidad Tecnológica through the academic corpus UTRNG-CA-8 it was necessary to analize a similar program that is being carried out bythe technological fertilization package for corn sowing land in the State of Morelos. This software is named Fertilization System for the State of Morelos [1], but has limited information in the agricultural census of the municipalities and towns of Morelos and because it did not have continuity in its development nor operation as a computer software, it remained in the obsolescence for the staff who built it could no longer continue to improve it.

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Due to the information above and the fact that the State of Guerrero does not have a technological tool that can automatically obtain the treatment of fertilization based on the agricultural census motivated INFAP researchers, professors of the academic corpus UTRNG-CA-8 of the Universidad Technológica, and students of the Information Technology Engineering to support as collaborators to develop the prototype of website and mobile application that would allow to obtain the technological treatment of fertilization for the crop fields especially of corn located in the Northern region of Guerrero in a first phase.

3.4 Software Development Methodology

Software has become the key element in the evolution of computer-based systems and products, as well as one of the most important technologies in the world. Currently the software evolves according to a set of laws that have remained unchanged over 30 years. The purpose of software engineering is to provide a general framework to build software with higher standars of quality. [5]

For the construction of the website and the mobile application, a software-engineering-based for the development of software methodology was used; cascade or classic model. The activities are described according to the stages in which this methodology is integrated as follows:

Stage	Description
Collection of Information	In this first phase, interviews are conducted to collect the necessary information to develop the website and mobile application for the INIFAP.
Analysis	At this stage all the information collected through interviews and visits to Dr. David H. Noriega Cantú, a researcher of fruit trees and agricultural health, was analyzed. The information collected will be processed and will serve as the basis for the design.
Design	The architecture obtained through the analysis will be molded to create the design and development of the website and mobile application in a simple and understandable way for INIFAP staff as it will serve as the basis for implementation.
Implementation	The programming of the website and mobile application will be carried out using the software Dreamweaver, Sublime Text 3, Apache Cordova, Android SDK and Ionic. The encoding, compilation and implementation begins.
Testing	The website and mobile application are tested once the prototypes are finished, in order to discard all kinds of failure while operating.
Documentation	In this stage all relevant information that is emerging in the realization of the website and mobile application will be documented to support the administrator and users of the website.

Table 1 Stages of software development methodology.

4. Results

The results obtained in this first phase of the project are two prototypes: one is a website and the other a mobile application, which are described below. From the website a main menu can be displayed with the corresponding options according to the login profile either as a user or an administrator, as it is seen on figure 1 and 2 respectively.

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Figure 1 Normal User View of the Options Menu.

Figure 2 Administrator View of the Options Menu.

The Map option shows the States of the Mexican Republic; then if you click on the State of Guerrero, its regions are shown; then the municipalities until you reach the level of towns from each municipality of the Northern region of Guerrero, as shown In Figures 3, 4 and 5 respectively.

Figure 3 Map of the Mexican Republic.

Figure 4 Map of Guerrero state.

We can see the towns that belong to the municipality of Cocula, Guerrero. One of those towns, Apipilulco, is chosen as an example to obtain the fertilization technological package according to some corn sowing land.

For this calculation criteria such as PH, slope, length, latitude, and type of crop are also taken. At the same time it is possible to see its source of fertilizer as well as the amount in kilograms depending on the PH degree of the soil; if it is lower than 7.5, it will be phosphonitrate; yet, if it is higher than 7.5, it will be ammonium sulphate with its respective phosphorus source (DAP); thus obtaining both the amount in kilograms as well as the type of fertilizer required by the land to be planted.

5. Conclusions

Subsequently, in a first phase of the collaboration project between INIFAP and UTRNG significant progress was made, which is described below:

– A database was created under the name of inifapbd that includes the following tables: Users, Identification, Physical Characteristics, Chemical Structure, LandUse, Crop, States, Municipalities and Towns, through MySQL

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- The graphic interfaces for the WebSite were designed as web forms for interaction with users, through Dreamweaver and Sublime Text 3.

- User, Search, Delete, and Update modules were built.

- The level of security was constructed through roles, such as: administrator and user.

- Programming Langusges such as: PHP, JavaScript, HTML, Apache Córdoba, Android SDK e IONIC were used.

- The Fertilizer Technological Package was generated for corn crop fields from every municipality and town in the Northern region of Guerrero.

What is intented to be developed on a second phase of the project will be explained through the following recommendations and further works:

- To host the Web system in a hosting under a sub domain from the main domain of INIFAP or that it is subcontracted by a third party to the Intitution.

- To update the records of the crop lands, and its owners to cover one hundred percent the agricultural census for each and every one of the regions in Guerrero State.

- To debug the algorithm that performs by mean of a chemical formula the calculos of fertilization in the corn crop fields so that the endowment of the packages per kilogram would precise for each landowner.

- To build more modules on the WebSite to cover other type of crops such as: jamaica, peanut, sorghum, etc.

- To perform another agricultural census with the porpuse of updating the current one that goes back to 1998.

- To provide the mobile application with remote data access so researches can be able to send and receive information based on the implementation of new modules in order to make the information processing more efficient depending on the event.

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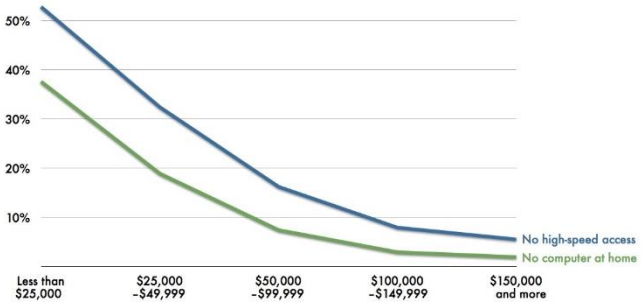

Graphic 1 Poor people have less access to high-speed internet and computers at home

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