Access Management in Medical Image Databases Based on New Format and Contents Protection with Inverse Pyramid Decomposition

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Abstract:
In the paper is presented one new approach for creation and management of medical image databases with multi-layer access, based on the Inverse Pyramid Decomposition (IPD). The archived visual data is compressed using the special IDP format, presented in detail in this paper. The new approach offers flexible tools for multi-layer transfer of the processed information with consecutively quality improvement, together with reliable content protection ensured by digital watermark insertion and data hiding. The IDP permits insertion of multiple watermarks in same file. Part of the visual information (specific regions of interest in the medical images) is hidden for the low access levels and could be revealed by authorized users only.

Keywords: Hierarchical access in medical image databases, management of image databases, image content protection, compressed file format.

1. Introduction

The multimedia databases (MD) are increasingly important part of computer and information sciences. Recently the large consortiums of hospitals in Western Europe already have or are in process of creating their own patients information systems, which enable total interchange of data and together with this, are still compatible with the individual way of working of each hospital. Electronic medical health records (EMHR) contain wide variety of multimedia objects (images, electronic documents, video, audio, etc.). The management of such databases should satisfy significant number of contradictory requirements: easy and reliable data access, hierarchical access structure, content protection, efficient archiving, high quality, etc. Additional important requirements arose concerning the feature extraction, quality level, and information filtering. In spite of the already performed work in image and audio processing, image analysis and pattern recognition are still not adequately addressed. The usual approach in the contemporary practice is to use Digital Imaging and Communications in Medicine (DICOM) standard [1]: the images are compressed and stored and their accessibility and content protection depends on the MD management. In medicine to date, virtually all picture archive and communication systems (PACS) retrieve images simply by indices based on patient name, technique, or some observer-coded text of diagnostic findings [2, 3]. There are a number of uses for medical image databases, each of which would make different requirements on database organization. Classification of images into named or coded diagnostic categories may suffice for retrieving groups of images for teaching purposes. One of the most powerful contemporary tools for image archiving is the JPEG2000 image compression standard, which offers many features that support interactive access to large images [4, 5] (highefficiency compression, resolution scalability, quality scalability, and spatial random access). The main disadvantage is that JPEG2000 does not offer tools for layered content protection and access.

In the paper is presented one new approach for creation and management of medical image databases with multi-layer access, based on the Inverse Pyramid Decomposition (IPD), which offers various tools for layered transfer of the processed visual information with consecutively quality improvement, together with reliable content protection through insertion of resistant and fragile watermarks: the resistant watermark is used to prove the document authenticity, while the fragile watermark is used to prevent the access to some important parts of the archived information. For lower access levels part of the information is hidden, such as: (for example) personal patients' data, specific regions of interest (ROI) in the corresponding medical images, etc., and could be revealed by authorized users only (in the higher access levels).

The paper is arranged as follows: In Section 2 is presented the main idea of the IPD decomposition; in Section 3 is described the new format, created for the IDP image decomposition; in Section 4 is described the method for multi-layer watermarking and data hiding; in Section 5 is presented the approach for the database management, and Section 6 contains the Conclusions.

2. Basic principles of the IPD decomposition

The 2D matrix [B], which represents the digital image, could be transformed using the Inverse Pyramid Decomposition (IPD) [6]. For this, the image matrix is first divided into blocks of size $2^n \times 2^n$. The corresponding sub-matrix for each image block $[B(2^n)]$ is decomposed in accordance with the relation:

$$[B(2^n)] = [\tilde{B}_0(2^n)] + \sum_{p=1}^{r} [\tilde{E}_{p-1}(2^n)] + [R(2^n)], \text{ for } r < n-1, \qquad (1)$$

where the number of decomposition components is $(r+2)$. Here $[R(2^n)]$ is a residual component, which is equal to zero for $r = n - 1$. Each component in Eq. (1) is a matrix of size $2^n \times 2^n$, corresponding to the decomposition layer p.

The <u>*First decomposition component*</u>, $[\tilde{B}_0(2^n)]$ calculated for the layer $p = 0$, is a coarse approximation of the block $[B(2^n)]$. It is obtained through 2D inverse orthogonal transform (OT) of the block $[\tilde{S}'_0(2^n)]$ in correspondence with the relation:

$$[\tilde{B}_0(2^n)] = [T_0(2^n)]^{-1} [\tilde{S}'_0(2^n)][T_0(2^n)]^{-1}, \qquad (2)$$

where:

$[T_0(2^n)]^{-1}$ - the 2D OT matrix, $[\tilde{S}'_0(2^n)]$, of size $2^n \times 2^n$;

$$[\tilde{S}'_0(2^n)] = FQ_0^{-1}\{[\tilde{S}_0(2^n)]\} = FQ_0^{-1}\{FQ_0\{[S_0(2^n)]\}\}. \qquad (3)$$

The terms $FQ_0\{\bullet\}$ and $FQ_0^{-1}\{\bullet\}$ are correspondingly operators for filtration and quantization of $[S_0(2^n)]$ and for dequantization of $[\tilde{S}_0(2^n)]$ in the decomposition layer $p = 0$. In result of the operation, performed by $FQ_0\{\bullet\}$, are selected and quantized the pre-selected high-energy coefficients in the matrix $[S_0(2^n)]$, which define $[\tilde{S}'_0(2^n)]$. In result of the performance of the inverse operator $FQ_0^{-1}\{\bullet\}$ and after the inverse operation, represented in Eq. (2), is calculated the component $[\tilde{B}_0(2^n)]$. The term $[S_0(2^n)]$ in Eq. (3) is calculated after direct 2D OT of the matrix $[B(2^n)]$, i.e.:

$$[S_0(2^n)] = [T_0(2^n)][B(2^n)][T_0(2^n)]\,. \tag{4}$$

Here $[T_0(2^n)]$ is the matrix for 2D OT, of size $2^n \times 2^n$, which could be of any kind: (DFT, DCT, etc.), and whose inverse matrix is $[T_0(2^n)]^{-1}$.

The remaining decomposition components from Eq. (1) are the <u>*approximating matrices*</u> $[\tilde{E}_p(2^{n-p})]$ for decomposition levels $p = 1, 2,.., r$. These matrices comprise the sub-matrices $[\tilde{E}_p^{k_p}(2^{n-p})]$, of size $2^{n-p} \times 2^{n-p}$ for $k_p=1,2,\dots,4^p$, obtained as a result of the quad-tree division of $[\tilde{E}_p(2^{n-p})]$. Each sub-matrix $[\tilde{E}_p^{k_p}(2^{n-p})]$ is then defined as:

$$[\tilde{E}_{p-1}^{k_p}(2^{n-p})] = [T_p(2^{n-p})]^{-1}[\tilde{S}_p'^{k_p}(2^{n-p})][T_p(2^{n-p})]^{-1} \text{ for } k_p=1,2,..,4^p, \tag{5}$$

where 4^p is the number of the quad-tree branches in the decomposition level p;

$[T_p(2^{n-p})]^{-1}$ is a matrix of size $2^{n-p} \times 2^{n-p}$ in the decomposition level p, used for the inverse 2D OT;

$$[\tilde{S}_p'^{k_p}(2^{n-p})] = FQ_p^{-1}\{[\tilde{S}_p^{k_p}(2^{n-p})]\} = FQ_p^{-1}\{FQ_p\{[S_p^{k_p}(2^{n-p})]\}\}\,; \tag{6}$$

The terms $FQ_p\{\bullet\}$ and $FQ_p^{-1}\{\bullet\}$ are correspondingly the operators for filtration and quantization of $[S_p^{k_p}(2^{n-p})]$ and for dequantization of $[\tilde{S}_0(2^n)]$ in the layer p.

Each transform is defined by the equation:

$$[S_p^{k_p}(2^{n-p})] = [T_p(2^{n-p})][E_{p-1}^{k_p}(2^n)][T_p(2^{n-p})]\,, \tag{7}$$

where

$[T_p(2^{n-p})]$ is a matrix of size $2^{n-p} \times 2^{n-p}$ in the level p for each block $[E_p^{k_p}(2^{n-p})]$ when $k_p=1,2,\dots,4^p$ in the difference matrix, defined by the relation:

$$[E_{p-1}(2^{n-p})] = \begin{cases} [B(2^n)] - [\tilde{B}_0(2^n)] & \text{for} \quad p = 1; \\ [E_{p-2}(2^{n-p})] - [\tilde{E}_{p-2}(2^{n-p})] - & \text{for } p = 2,3,..,r. \end{cases} \tag{8}$$

In result of the decomposition (Eq. 1) for each block $[B(2^n)]$ are defined the following spectrum coefficients:

- from the level $p = 0$ - all non-zero coefficients in $[\tilde{S}_0'(2^n)]$;
- from levels $p = 1, 2, \dots, r$ - all non-zero coefficients $[\tilde{S}_p'^{k_p}(2^{n-p})]$ for $k_p=1,2,..,4^p$.

The spectrum coefficients of same spatial frequency from all image sub-blocks are arranged in common massifs in accordance with the decomposition level, and then - losslessly coded. With this the image coding is finished.

The processing of color images is performed in the way already presented above for grayscale images. For this, the kind of color transform is first selected. This could be RGB, RCT, Rec.601-2, KLT (Karhunen-Loeve Transform), etc. The color data coding could be one of the kind: 8:8:8, 4:4:4, 4:2:2, or 4:2:0. Depending on the color transform, 3 pyramids are built, corresponding to the main components. The decomposition follows the rules, given above for the image brightness processing. In result, significant compression of the archived image is obtained.

3. IPD format

The everyday medical practice requires flexible approach in image compression and transfer. The approach, based on the IDP decomposition offers fast initial image transfer (the image approximation, which corresponds to the low decomposition level) without many details, which are after that sent on request only. For such applications the IDP method is extremely suitable because it permits layered image transfer with increasing resolution and quality. Additional ability is to permit setting of Regions of Interest (ROI), which to be immediately accessed and then restored with highest quality. In such applications the data structure is more complicated, because the header should comprise not only the information for each decomposition layer, but information about the ROI size and position as well.

The implementation of the IDP decomposition and its applications aimed at the medical image databases management require the creation of a new format. The information, which accompanies the coded data, should comprise the basic characteristics of the decomposition: the number of decomposition levels used; the orthogonal transform, selected for each level and the corresponding sets of coefficients (i.e. the masks of retained coefficients); the kind of color transform (for color images); the quantization values; the pixels scanning direction (vertical, horizontal, diagonal), and the kind of entropy and run-length coding of coefficients' data. This information is saved in the coded data header and is needed for the proper decoding. The header comprises 3 main parts: general header, special data sub-header and sub-header for color data. The coded data information is divided into 3 big groups: lowest level (No.1), middle levels (from level 2 up to level N-1) and highest level (N), in accordance with the decomposition. The interactively selected ROI is processed as a kind of a sub-block or as a group of sub-blocks.

The data structure of the compressed image file after IDP decomposition is shown in Table 1. The brief definition of the basic header data is given below. The names are created as abbreviations of their contents.

Table 1. Description of the IDP file Main Header

<table>
<tr><td>Main header</td><td>Special data
sub-header</td><td>Sub-header
color data</td><td>Additional
data</td><td>Packet 1
(Lowest level)</td></tr>
<tr><td colspan="4">Sub-header for level 2</td><td>Data Packet 2</td></tr>
<tr><td colspan="4">Sub-header for level 3</td><td>Data Packet 3</td></tr>
<tr><td colspan="4">---</td><td>-----------</td></tr>
<tr><td colspan="4">Sub-header for level N-1</td><td>Data Packet N-1</td></tr>
<tr><td colspan="4">Sub-header for level N</td><td>Data Packet N</td></tr>
</table>

The compressed file header comprises following:

Kuhdr **-** main header

Rlbytecnt (unsigned 32 bit) - number of bytes after run-length coding;

Bytecnt (unsigned 32 bit) - final number of bytes, after entropy coding;

Prgprm (unsigned, 16 bit) **-** program parameters, containing all 1-bit parameters (flags), as follows: the way of picture scanning, data arrangement, kind of color transform, etc.

Prgprm1 (unsigned, 16 bit) - initial and end level of the truncated pyramid and maximum possible number of pyramid levels for the processed image.

Kusdh - special data sub-header

Definition of the retained coefficients:

ILVFL (unsigned, 16 bit) - mask defining the retained coefficients in the initial (lowest) pyramid level;

MLVFL (unsigned, 16 bit) - mask defining the retained coefficients in the middle pyramid levels (from 2 up to N-1);

ELVFL (unsigned, 16 bit) - mask defining the retained coefficients in the highest pyramid level (N);

Lossless data coding:

Rltype (unsigned char) – defining the kind of Run-length, used for the lossless coding of the coefficients' values.

Information about the quantization used:

DivCC (char) - division coefficient for the first pyramid level

Approximation methods:

LVLidp (unsigned char) - defines the selected approximation method for each level (WHT, DCT, etc).

Global information about the processed image:

Nn (unsigned, 16 bit) - size of the original image (vertical)

NHn (unsigned, 16 bit) - size of the original image (horizontal direction)

The color data is processed in similar way.

Kusdhc - sub-header for color data

Global information:

ILVc (unsigned char) - initial pyramid level

ELVc (unsigned char) - end pyramid level

Definition of the retained coefficients:

ILVFLc (unsigned 16 bit) - mask defining the retained coefficients in the initial pyramid level;

MLVFLc (unsigned 16 bit) - mask defining the retained coefficients in the middle pyramid levels;

ELVFLc (unsigned 16 bit) - mask defining the retained coefficients in the highest pyramid level;

Information about the quantization used:

DivCCc (char) - division coefficient for the first pyramid level;

Approximation methods:

LVLidpc (unsigned char) - defines the selected approximation method for each level (WHT, DCT, etc).

Global information about the processed image:

Nnc (unsigned, 16 bit) - the size of the original image (vertical)

NHnc (unsigned, 16 bit) - the size of the original image (horizontal)

Uvpxlc (unsigned, 16 bit) - used color standard (4:1:1, 4:2:2, etc.)

The **additional data** comprises information about other parameters, necessary for definition of the selected kind of lossless data coding or when multi-view or multi-spectral images are processed.

As it is easy to notice, the number of bits used for the representation of the main parameters permits to add more information about various kinds of image processing.

4. Resistant image watermarking, based on the 2D-CHT

For the resistant watermarking is used IDP decomposition with Complex Hadamard Transform. Specific for this transform is that the transform coefficients have real and imaginary parts. The watermark data is inserted in the phases of selected spectrum coefficients, obtained with 2D Complex Hadamard Transform (2D-CHT) using "arranged" Complex Hadamard matrix for the image matrix *[B(N)]* [7] processing.

4.1. Resistant watermark embedding

The method for resistant watermark embedding could be used for any kind of images, grayscale or color. The watermark could be a binary image or a data sequence. The basic requirement is the watermark data to be smaller than the protected image. The watermark is embedded in the brightness information of the protected image.

The mathematical presentation of the method follows below.

The image matrix $[B(2^n)]$ of size $N\times N$ ($N=2^n$) is first processed with direct 2D-CHT:

$$[S(2^n)] = [CH(2^n)][B(2^n)][CH(2^n)]\,. \quad (9)$$

Here $[S(2^n)]$ is the matrix of the discrete image spectrum; $[CH(2^n)]$ - arranged matrix, defined by the natural complex Hadamard matrix $[CH_0(2^n)]$ with elements:

$$ch_0(t,q) = j^{tq}\, h_0(t,q) \text{ for } t, q = 0,1,..,2^n -1, \quad (10)$$

$$h_0(t,q) = \begin{cases} 1 & \text{for} \quad n=2; \\ (-1)^{\sum_{r=3}^{n}\left\lfloor \frac{t}{2^{r-1}} \right\rfloor \left\lfloor \frac{q}{2^{r-1}} \right\rfloor} & \text{for } n=3,4,.. \end{cases}$$

The arranged matrix $[CH(2^n)]$ is obtained from the natural one, $[CH_0(2^n)]$ after rearranging its rows in such a way, that the number of sign changes for the elements in the row q to be increased by one in the next row, (q+1). The coefficients of the matrix $[S_0(2^n)]$, are:

$$s_0(u,v) = \sum_{i=0}^{2^n-1}\sum_{k=0}^{2^n-1} B(i,k) e^{-j\frac{\pi}{2}(ui+vk)} h_0(u,i) h_0(v,k) \quad \text{for } u, v = 0,1,..,2^n-1, \quad (11)$$

where $B(i,k)$ is the element of the original image $[B(2^n)]$. For the calculation of coefficients $s(u,v)$, obtained using the matrix $[CH(2^n)]$, is necessary to rearrange the coefficients $s_0(u,v)$. Each complex coefficient $s_0(u,v)$ is then represented as:

$$s_0(u,v) = s_{0,Re}(u,v) - j s_{0,Im}(u,v) = M_0(u,v) e^{-j\varphi_0(u,v)}, \quad (12)$$

where:

$$s_{0,Re}(u,v)=\sum_{i=0}^{2^n-1}\sum_{k=0}^{2^n-1}B(i,k)h_0(u,i)h_0(v,k)cos[\tfrac{\pi}{2}(ui+vk)], \quad (13)$$

$$s_{0,Im}(u,v)=\sum_{i=0}^{2^n-1}\sum_{k=0}^{2^m-1}B(i,k)h_0(u,i)h_0(v,k)sin[\tfrac{\pi}{2}(ui+vk)]\,. \quad (14)$$

From all spectrum coefficients as suitable for watermarking are chosen the complex-conjugated couples $s(u,v)$ and $s^*(u,v)$ (with phases $\varphi(u,v)=-\varphi^*(u,v)$ and modules $|M(u,v)|=|M^*(u,v)|$) correspondingly. Each consecutive bit $w_r(p)$ of the watermark data p is inserted in the phases of coefficients $s(u,v)$ and $s^*(u,v)$ only, in correspondence with the relation:

$$\varphi_{w_r(p)}(u,v)=-\varphi^*_{w_r(p)}(u,v)=\begin{cases}\varphi(u,v)+\Delta, & if \quad w_r(p)=1;\\ \varphi(u,v)-\Delta, & if \quad w_r(p)=0.\end{cases} \quad (15)$$

Here $\varphi_{w_r(p)}(u,v)$ and $\varphi^*_{w_r(p)}(u,v)$ are the phases of the watermarked coefficients $s_{w_r(p)}(u,v)$ and $s^*_{w_r(p)}(u,v)$. The watermark data is represented by the binary sequence $w_r(p)$ for $r = 1,2,..,R$ (R is the number of the watermark binary elements). The parameter Δ is the angle, which defines the watermark “depth”, “transparency” and the resistance against pirates’ attacks. The sequence of bits $w_r(p)$ is obtained after performing operation “XOR” both for each bit of the watermark and the corresponding bit from a pseudorandom sequence, which represents a secret (private) or public key, used for the watermark encryption. In this case the autocorrelation function of the sequence $w_r(p)$ is chosen to be of the kind “delta-pulse”. This ensures high accuracy for the watermark detection and extraction. In case that the currently processed complex spectrum coefficient, which should be watermarked, has zero amplitude, the corresponding binary value of the watermark is omitted and the binary symbol from the pseudorandom sequence only remains, because “XOR” is not applied. In result, the errors in the extracted watermark elements are reduced, because the spectrum coefficients of zero amplitude have zero phases as well, and they are practically not suitable for watermark elements extraction.

The coefficients of the rearranged spectrum matrix $[S_w(2^n)]$ are:

$$s_{w_r(p)}(u.v)=M(u,v)e^{-j\varphi_{w_r(p)}(u,v)} \quad (16)$$

The matrix $[S_w(2^n)]$ is processed with inverse 2D-CHT and as a result is obtained:

$$[B_w(2^n)]=4^{-n}[CH(2^n)]^*[S_w(2^n)][CH(2^n)]^*, \quad (17)$$

where

$$[CH(2^n)]^*=2^n[CH(2^n)]^{-1}.$$

The pixels of the watermarked image are defined by the relation:

$$B_w(i,k)=\sum_{u=0}^{2^n-1}\sum_{v=0}^{2^n-1}s_w(u,v)e^{j\frac{\pi}{2}(ui+vk)}h_0(u,i)h_0(v,k) \text{ for } i,\ k = 0,1,..,2^n-1. \quad (18)$$

The method for resistant watermarking, presented above, has two main advantages:

- The watermark is “transparent”, i.e., not noticeable, because the watermark data is embedded in the phases of the selected coefficients;
- The method permits to insert significant number of watermark data (higher than for other similar methods), because for the watermarking could be used each of the decomposition layers.

These advantages of the new method make it extremely suitable for the presented application (content protection in medical image databases), because the quality of the archived images is of highest importance.

4.2. Watermark detection

For the resistant watermark detection in unknown image are performed the operations, represented by Eqs. (11-14) above. The presumption here is that the searched watermark is one of a set of known watermarks, i.e. it is checked if the document had been watermarked with one of these watermarks.

The watermark detection is performed as follows: First, should be checked whether in the image had been inserted the watermark p, which is one of the known *D* possible signs. For this is calculated the mutual correlation $C_{m,p}$ between the m^{th} and p^{th} watermark, the first of which is one of the *D* possible, and the second is used for watermarking of the complex-conjugated coefficients $s(u,v)$ and $s^*(u,v)$ of the unknown image:

$$C_{m,p} = \sum_{r=1}^{R} [\,\varphi(u,v) + \Delta_r(p)]\,\Delta_r(m) = A(m) + B(p,m) \quad (19)$$

for $p, m = 1,2,..,D,$

where *D* is the number of searched watermarks; $[\varphi(u,v) + \Delta_r(p)] = \varphi_{w_r(p)}(u,v)$ is the phase of the marked spectrum coefficient $s_{w_r(p)}(u,v)$ of the matrix $[S_w(2^n)]$, which contains the p^{th} watermark data;

$$\Delta_r(p) = (-1)^{w_r(p)}\Delta = \begin{cases} +\Delta \ \ if \ \ w_r(p) = 1; \\ -\Delta \ \ if \ \ w_r(p) = 0, \end{cases}$$

$$A(m) = \varphi(u,v)\sum_{r=1}^{R}\Delta_r(p) \approx 0 \ \ for\ R >> 1,\ \ B(p,m) = \sum_{r=1}^{R_p}\Delta_r(p)\Delta_r(m). \quad (20)$$

In case that the investigated spectrum coefficients are not marked, $\Delta_r(p) = 0$ and $C_{m,b} \approx 0$; else:

$$C_{m,p} \approx \begin{cases} \sum_{r=1}^{R} [\Delta_r(m)]^2 = R\Delta^2 \ \ if \ \ m = p; \\ \sum_{r=1}^{R} \Delta_r(m)\Delta_r(p) \approx 0 \ \ if \ \ m \neq p. \end{cases} \quad (21)$$

The decision for the watermark data p detection is taken in accordance with the relation:

$$p = \begin{cases} Yes, \;\; if \;\; [\, C_{m,p} / R\Delta^2 \,)] \geq \theta; \\ No, \;\; - \;\; in\ other\ cases. \end{cases} \quad \text{for} \quad m, p = 1, 2, \dots, D, \quad (22)$$

where θ is a pre-defined threshold in the range $0 < \theta < 1$.

The so described **watermark detection** is “blind”, i.e. it does not need the original image, but the watermark only.

4.3. Resistant watermark extraction

For the resistant watermark extraction is needed the original image. The presumption is, that the owner is the person, authorized to embed the watermark and he/she has the original. After the phase spectrums of the original and the watermarked images had been calculated, the phases of the corresponding coefficients are subtracted and is defined the sequence, obtained after applying the “XOR” function on the watermark and the pseudorandom sequence, which is the encryption key. The watermark is obtained after performing “XOR” for the sequences of phase differences and the key.

4.4. Fragile watermark insertion

The IPD decomposition permits insertion of fragile watermark also. In general, this is an additional decomposition layer. The watermark data is first losslessly coded and the so-obtained data is then added to some of the decomposition levels data. In the quality of a fragile watermark could be used any image of size equal or smaller than that of the protected one. After image restoration, the fragile watermark is visualized overlaid on the corresponding decomposition level, which prevents (hides) the visualization of the approximation. The removal of the fragile “hiding” watermark is carried out using a password.

5. Access Management in medical image databases

The layered approach for image archiving, based on the IPD decomposition, permits to develop special flexible tools for image database management. The basic idea is that any image in the database could be visualized layer by layer with increasing resolution. The visualization starts with the coarse approximation of the archived image, calculated from the lowest decomposition level data, which corresponds to lower access also. The next approximation (of higher quality) is visualized only in case that the user has permission for this, and proves it (for example, with a password). Together with the better quality, the system reveals on request (and if password is available) additional personal information. In case, that the image (or a part of it, containing a ROI) is hidden, it is visualized only if the permission (password) for the corresponding decomposition level is provided.

The image preparation for the image database with layered access is shown on Fig. 1. The image is archived layer by layer and the watermarks are inserted together with the image processing. The ROI (if there is one in the image) is processed in such a way, that to permit direct access for authorized users (separate pyramid is developed for the ROI representation).

The structure of the hierarchical access to the image database contents is shown on Fig. 2.

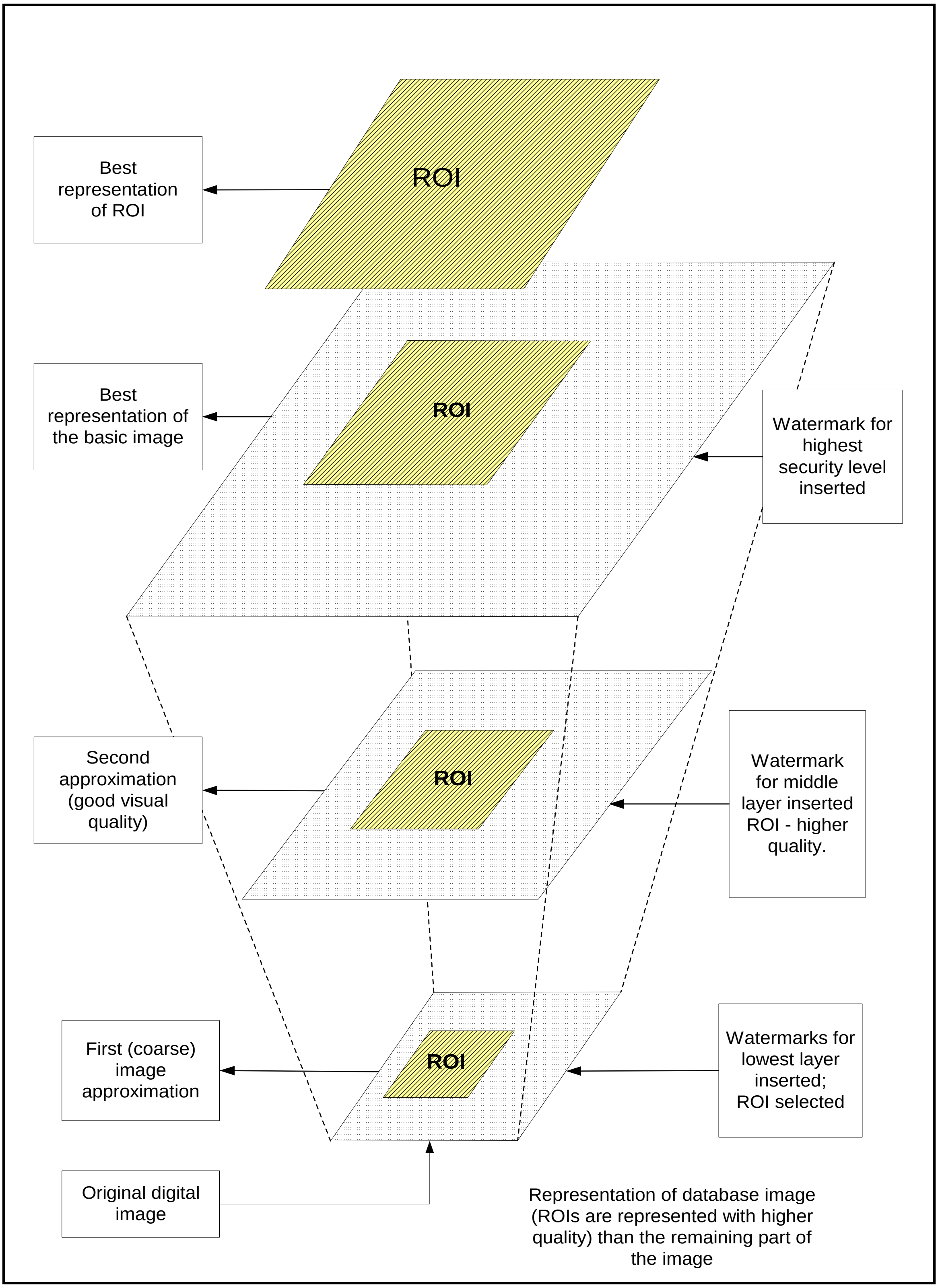

Figure1. Three-layer image decomposition with content protection

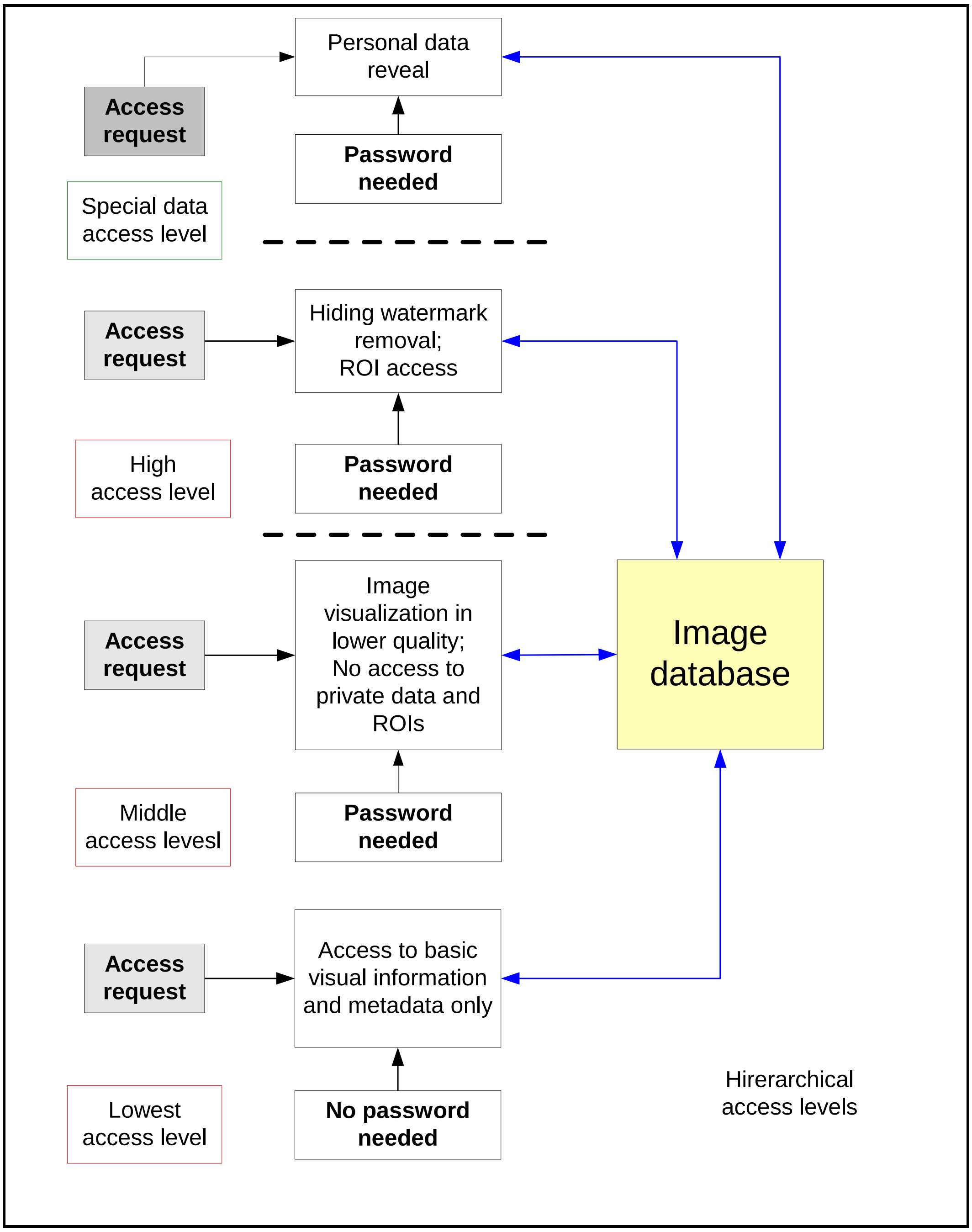

Figure 2. Hierarchical access to the image DB

6. Conclusions

The proposed method for creation of medical databases with image content protection, based on the IPD, offers various tools for image processing and archiving. The general part of the database information could be used for various applications: disease description, disease history and treatment, statistics, information exchange, students learning, etc [8]. The main advantages of the new method are:

- It offers flexible layered access to the archived information, depending on the user authorization;
- It ensures immediate access to preset ROIs for authorized users;
- It offers reliable content protection with multiple resistant and fragile watermarks, inserted in the consecutive decomposition levels. The knowledge of the algorithm and the possession

of the decoding tools do not permit watermark extraction and visualization of the protected visual information. For this is needed a password, or other similar tool;

- The special IDP format could be further developed with minor changes (additions) in order to cover more applications;
- Any change, noticed in the fragile watermark, proves unauthorized access and image editing;
- The detection or extraction of the resistant watermark prove the document authenticity;
- The ability to insert more than one watermark in the same image ensures higher security for the original image content;
- The resistant watermark is inserted in the phases of the transform coefficients, and as a result, the watermark is "transparent", i.e. – invisible;
- The layered approach for image processing permits the creation of general models for object description and representation. In the case, when RST-invariant transformations are used (for example, the 2D Mellin-Fourier transform) the objects representation is RST-invariant as well, which could be used for object classification and evaluation;
- A modification of the RST-invariant object representation method permits the description to be contrast-invariant as well [9];
- The proposed database management corresponds to the contemporary methods for content- and context-based data search. It permits to implement some up-to-date methods, based on Neural networks;
- The IDP method and the flexible database management offer layered object search in image databases, similar with the human way for object recognition (starting from slight similarity and continuing up to higher similarity and sure identification).

The proposed database management permits further development aimed at efficient archiving of sequences of medical images.

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