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(*)Number: ITU-T Rec. T.814 | ISO/IEC 15444-15

(*)Title: INFORMATION TECHNOLOGY – JPEG2000 IMAGE CODING SYSTEM – HIGH THROUGHPUT JPEG2000

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Patent Information (desired but not required for options 1 and 2; required in ITU, ISO and IEC for option 3 (NOTE))

No.	**Status** [granted/ pending]	**Country**	**Granted Patent Number or Application Number (if pending)**	**Title**
1	GRANTED	USA	9 332 258 B2	METHOD AND DEVICE FOR DISPLAY STREAM COMPRESSION
2				
3				
4				
5				
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10				

[X] Check here if additional patent information is provided on additional pages.

NOTE: For option 3, the additional minimum information that shall also be provided is listed in the option 3 box above.

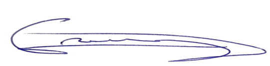
Signature (include on final page only):

Patent Holder: intoPIX SA

Name of authorized person: Gaël ROUVROY

Title of authorized person: Chief Executive Officer

Signature



Place, Date: Mont-Saint-Guibert, 19th June 2020

Appendix

Additional information provided by intoPIX in the frame of its choice of Option 3

1. Global overview pertaining to the decision of intoPIX to choose Option 3

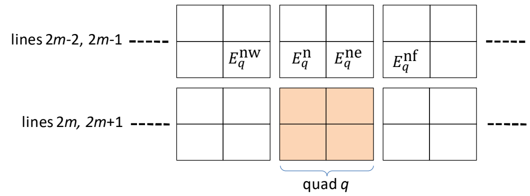
- The core technology standardized in ITU-T Rec. T.814 | ISO/IEC 15444-15 is an improved version of a fast block coding option for JPEG 2000, known as FBCOT.
- Initial FBCOT technology has been submitted by UNSW as a candidate technology in response to the JPEG XS Call for Proposals (wg1n71031). It is described in their submission available in wg1m72011 (June 2016, overview) and wg1m73021 (September 2016, full submission).
- Based on the evaluation of the 6 proposals submitted in response to the JPEG XS Call for Proposals in October 2016, a consensus was reached within ISO/IEC JTC1 SC29 WG1 (denoted WG1 in the following) to select as baseline for the upcoming JPEG XS Standard the technology proposed by intoPIX SA (wg1m73019) and by Fraunhofer IIS and Stuttgart University (wg1m73018). FBCOT technology was not selected in this process due to concerns related to FBCOT fulfilling the strong JPEG XS requirements in terms of complexity and latency. The JPEG XS project then entered a collaborative phase within WG1, welcoming all contributions to further improve the selected baseline, leading to the publication of the new JPEG XS Standard in 2019 (ISO/IEC 21122-1).
- Instead of contributing to the JPEG XS collaborative phase, FBCOT submitters (UNSW) decided to propose a new project perfectly fitted for FBCOT and aiming at the standardization of a high-throughput version of JPEG 2000 Part-1 (ITU-T Rec. T.800 | ISO/IEC 15444-1). The use cases of this new project were mainly those of JPEG 2000 Part-1 that would benefit from a higher throughput, as described in the High-Throughput JPEG 2000 (HTJ2K) Call for Proposals (wg1n76037).
- The only submitted technology in response to this Call was the FBCOT algorithm, which lead to the now-published JPEG 2000 Part-15, aka “High Throughput JPEG 2000”.
- FBCOT submission for HTJ2K did contain however subtle differences compared to their initial submission in 2016. IntoPIX SA became aware of these subtle differences only very recently and this triggered the present patent statement.
- Among these differences, the coding of a single exponent bound per group of samples (instead of one exponent per sample in the 2016 submission) allows for a significant complexity reduction, unreachable in their initial submission. This is however a mechanism already proposed in intoPIX SA submission for JPEG XS back in 2016, and covered by the patent indicated above.
- The reason why IntoPIX SA became recently aware of these differences is because HTJ2K promoters entered a more offensive dissemination phase, which forced intoPIX SA to further investigate HTJ2K. Up to now, there is no observed adoption of HTJ2K, while JPEG XS is steadily and increasingly adopted on its targeted markets. By specifically aiming low-latency use cases (low-latency is not a HTJ2K requirement, per wg1n76037) and markets where JPEG XS is adopted, by

publishing unfair and non-concerted comparisons with JPEG XS, and by benefitting from IP disclosed during the JPEG XS project, HTJ2K promoters not only slow down the JPEG XS adoption but more importantly create confusion among manufacturers seeing two different standards from the same Committee addressing the same use cases.

- IntoPIX SA has granted a license with RAND conditions for the above-mentioned patent when used in the context of JPEG XS Part-1 but is not prepared to do the same in the context of HTJ2K. IntoPIX SA indeed strongly believes that having two different standards with overlapping use cases coming from WG1 is harmful both for WG1 and for the Industry. Moreover, as one of the HTJ2K requirement is being a royalty-free standard, intoPIX SA believes HTJ2K should avoid making use of IP covered by intoPIX's patents and should modify the Standard towards their initial submission made for the JPEG XS Call for Proposals.

2. **Indication of which portions of the above document are affected**

- 6.2 Quad-based scanning pattern
  - Description of the groupment of wavelet output samples in quads (groups of 4 samples)
- 6.3 HT Cleanup decoding algorithm
  - Description of the Cleanup pass decoding
    Whole section and especially :
  - 6.3.2 Significance, exponents, predictors, MagSgn values and EMB pattern bits
    - Extraction of the magnitude exponent for a sample $\mathbf{E_n}$
    - Determining a common "exponent bound":
      "For insignificant samples, m_n=0, while for significant samples m_n is obtained by subtracting a 1-bit quantity $k_n \in \{0,1\}$ from **a common exponent bound $\mathbf{U_q}$ for the quad q** to which location n belongs"
      "…where the magnitude exponents of all samples in a quad q satisfy $\mathbf{E_n \leq U_q}$ **for n** $\in \{4q,4q+1,4q+2,4q+3\}$"
    - Prediction of the common exponent bound and coding of a residual value:
      "The decoder determines the quad's U_q value by adding an unsigned residual value u_q to an exponent predictor κ_q."
  - 6.3.6 Decoding of unsigned residuals
    - Describes the usage of an entropy coder for the exponent bound (U-VLC variable length code for the unsigned residual value)
  - 6.3.7 Determination of predictors and exponent bounds
    - Vertical prediction of the exponent bound:
      "Figure 6: Neighbourhood information used to form exponent predictors for quads in non-initial line-pairs of a block."



"$\kappa_q = \max\{1, \gamma_q \cdot (\max\{E_q^{nw}, E_q^{n}, E_q^{ne}, E_q^{nf}\}-1)\}$"

- 6.3.8 Unpacking the HT MagSgn bit-stream
  - Extraction of the bits under the exponent bound from the codestream:
    "Using the exponent bound U_q, significance pattern ρ_q and EMB patterns ϵ_q^{-k} and ϵ_q^{-1} for each quad, the decoder determines the number of bits m_n according to [$m_n = \sigma_n \cdot U_q - k_n$ for each $n \in \{4q, 4q+1, 4q+2, 4q+3\}$] and then recovers the HT MagSgn values for each sample, following the scanning pattern in Figure 2, by using procedure decodeMagSgnValue that appears below … "

- Annex C (informative): HT block encoding procedures
  Whole section and especially:
  - C.2. Bit-planes, exponents, MagSgn values and EMB patterns
    - Determination of one exponent bound for the quad (group of 4 samples):
      "For each quad q that contains at least one significant sample, **an upper bound on the magnitude exponents within that quad is identified as U_q.** These bounds are encoded via corresponding unsigned residuals u_q, with respect to exponent predictors κ_q, so that
      $U_q = u_q + \kappa_q \geq E_n$ for all $n \in \{4q, 4q+1, 4q+2, 4q+3\}$"
    - U_q is the maximum between the maximum exponent for each sample of the quad and the exponent predictor
      "$U_q = \max\{E_q^{max}, \kappa_q\}$, where $E_q^{max} = \max\{E_{4q}, E_{4q+1}, E_{4q+2}, E_{4q+3}\}$"
  - C.3. Cleanup pass encoding steps
    - Determination of one exponent bound for the quad, entropy coding of that exponent bound (vertical prediction + U-VLC), writing the bits of each sample under the exponent bound in the codestream:
      "As a first step, the encoder converts sample magnitude values μ_n to magnitude exponents E_n, following Formula (C.1)"…
      "For the first row of quads in a code-block, the exponent predictors are set to $\kappa_q=1$, while for all other quads, predictors are set according to Formula (5)" ($\kappa_q = \max\{1, \gamma_q \cdot (\max\{E_q^{nw}, E_q^{n}, E_q^{ne}, E_q^{nf}\}-1)\}$)
      "The encoder forms maximum magnitude exponents E_q^{max} for each quad q, according to Formula (C.3) then exponent bounds U_q according to Formula (C.2). From these, the unsigned exponent residuals are found using $u_q=U_q-\kappa_q$"
      "The encoder combines the ϵ_q^{-k} pattern produced by its CxtVLC table lookup with the computed magnitude exponent bound U_q and significance pattern ρ_q to

determine the number of MagSgn bits m_n that need to be emitted for each sample. Specifically, the encoder forms $\mathbf{m_n = \sigma_n \cdot U_q - k_n}$"
"The encoder generates the MagSgn bit-stream by passing the bit-count m_n and MagSgn value v_n to the emitMagSgnBits procedure defined in C.4, for each sample in turn, following the quad-based scanning order of Figure 2. **The emitMagSgnBits procedure emits the m_n LSBs of v_n to the MagSgn bit-stream.**"

3. Description of the Patents covering the above document

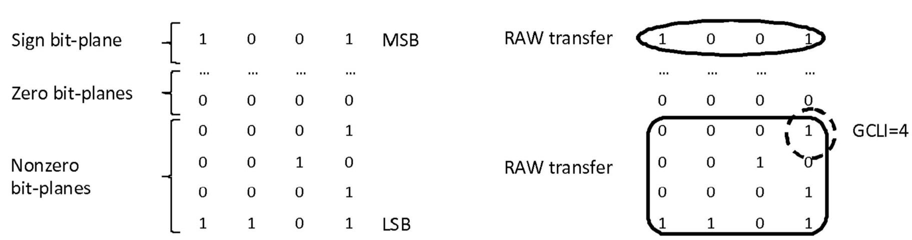
The patent covering the above document is patent US **9 332 258 B2.**

It describes a method and a device to compress a display stream wherein coefficients are grouped. For each group, the greatest coded line index (GCLI) is determined and only the GCLI lowest weight bits of the coefficients are copied into the output stream together with the value of the GCLI.

The description emphasizes that grouping 4 samples together has the best efficiency and represents a good trade-off between quality and complexity.

- The same size of groups has been used in the above documents and called those groups "quads"

In the patent, a GCLI value is computed for a group of 4 samples. GCLI is defined as the maximum exponent of the group.



- It is identical to the E_q^{max} value defined in the ITU-T Rec. T.814 | ISO/IEC 15444-15 document which is, in turn, identical to exponent bound U_q when the predictor kq is smaller than the Eqmax value.
    - o The document "High Throughput JPEG 2000(HTJ2K):Algorithm, Performance and Potential" edited by main authors of ITU-T Rec. T.814 | ISO/IEC 15444-15 and available on the htj2.com website qualifies the exponent predictor k_q as a "biased" predictor and emphasizes that it is rare that U_q is higher than E_q^{max}.
    "You can think of $\boldsymbol{e}_q$ as the most significant magnitude bit-plane within quad q, except that it is possible (though

rare) that the bound U_q is strictly larger than all four of the quad's magnitude exponents"

The patent describes that the GCLI value is entropy coded while the bits of lower weight are written in the codestream. The text describes an example GCLI entropy coder: A vertical prediction of the GCLI value is achieved before coding the prediction residual using a variable length code (signed unary coding in this case): "… In a second step, a vertical prediction is performed between two rows of GCLIs. The result is the difference between the GCLI value and the corresponding GCLI of the same subset of coefficients in the previously coded row. Predictive values may afterwards be coded following an easy-to-implement Unary Coding method."

- In the ITU-T Rec. T.814 | ISO/IEC 15444-15 document, the exponent bound (equivalent to GCLI) is predicted vertically from the above row and the residue is coded using a variable length code (U-VLC).

The claim 1, and its different characterisations found in claims 2, 3, 5, 6, 7, 8 are all included in the ITU-T Rec. T.814 | ISO/IEC 15444-15 document:

- Claim 1 is claiming the groupment of samples and the extraction of a GCLI value allowing to skip null MSB bitplanes in the codestream.
- Claim 2 & 3, are characterizing claim 1 with the usage of a wavelet transform as a first decorrelative process.
- Claim 5 & 6 concern the size of the groupment and further emphasize the groupment in groups of 4 samples. This size of groups is explained by the results shown Fig. 4.

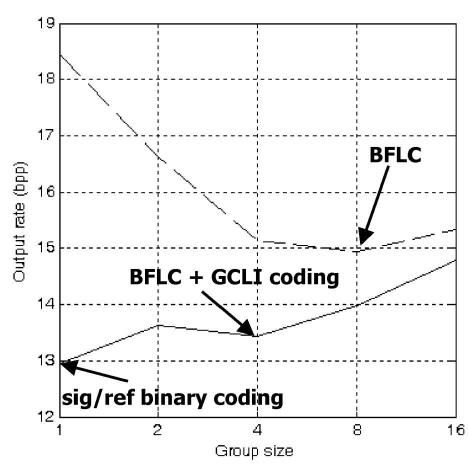


Fig. 4

- Claim 7 explains that bits under the GCLI value are sent in the codestream using a significance/magnitude representation
- Claim 8 is describing the entropy coding of the GCLI value.

In claim 10, the vertical prediction of GCLI is also claimed.

The initial submission of the FAST algorithm for the JPEG-XS standard described steps wherein one exponent per sample was coded (instead of one for the quad). That process is thus not in infringement of claim 1 because steps b) and c) were not done and other claims are dependent on claim 1. That process could thus be used without infringement of US 9 332 258 B2.

intoPIX is available to further explain the content of its patent and to discuss the possibilities for avoiding the use of its intellectual property in the HTJ2K standard.

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