HEVC Lossless Coding for Medical Image Compression

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Introduction – Motivation

- The amount of medical image data is increasing geometrically.
  - The number of scans itself has significantly increased recently.
  - Large amount of data is obtained from one single scan. (e.g. CT scan with 400 slices of 1024x1024 resolution → 800MB)
- Medical images need to be efficiently compressed.
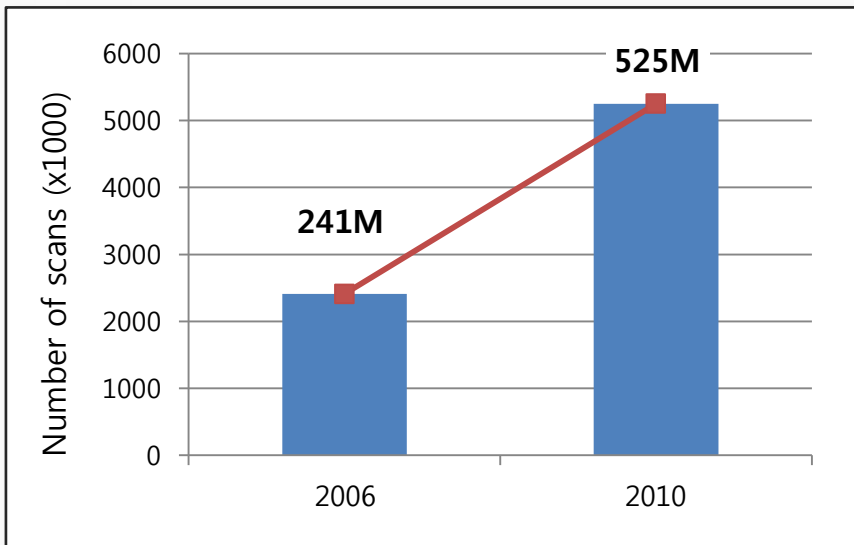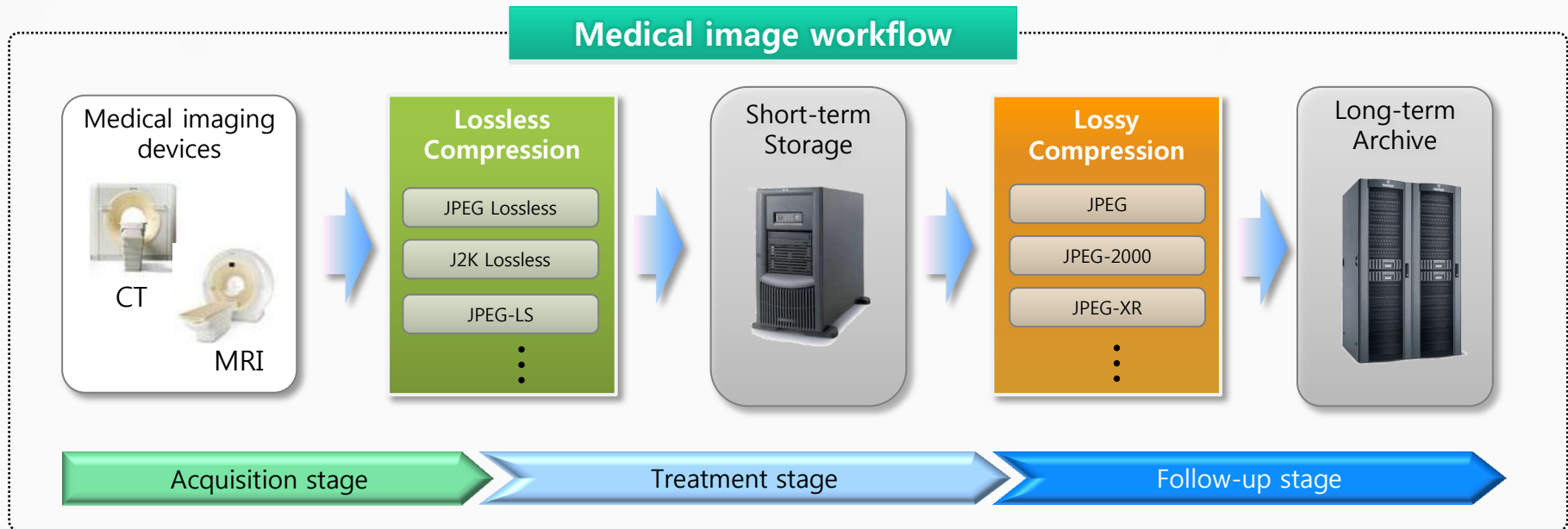
Number of CT scans per year in Korea (120%↑)
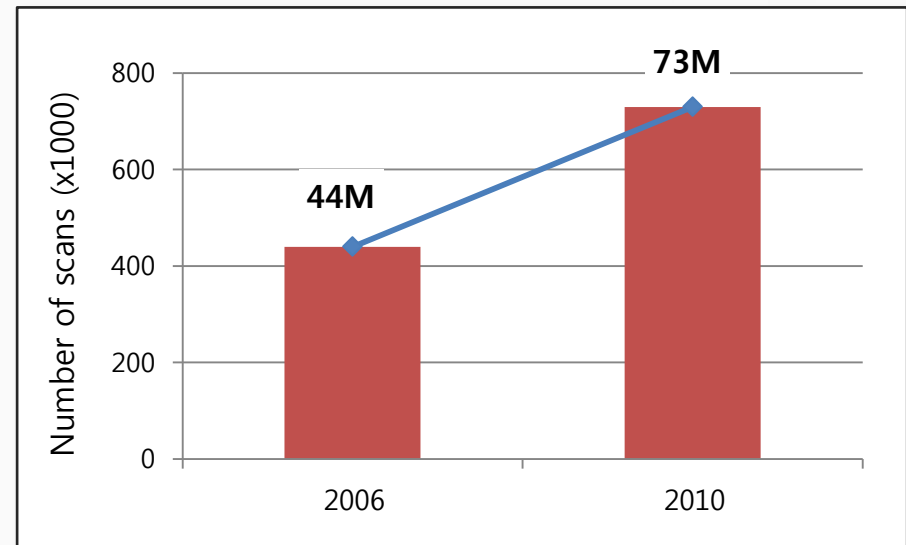
Number of MRI scans per year in Korea (66%↑)

- Medical images have to be losslessly compressed during the treatment period, since any distortion introduced by lossy compression can affect the clinical decision and lead to the legal problems.
- Currently, many ISO standards (e.g. JPEG, JPEG-LS, JPEG-2000 for still image coding, MPEG-2 and H.264/AVC for video coding) are employed by DICOM[1] standard for medical image compression.
- Medical image compression is one of the promising applications of HEVC.

Medical image workflow

Medical imaging devices	Lossless Compression	Short-term Storage	Lossy Compression	Long-term Archive
CT MRI	JPEG Lossless / J2K Lossless / JPEG-LS ⋮		JPEG / JPEG-2000 / JPEG-XR ⋮	

Acquisition stage	Treatment stage	Follow-up stage

1) DICOM: Digital Imaging and Communications in Medicine

Simulation Set-up

- The performance of HEVC lossless coding and its improvement proposed by JCTVC-J0230 is compared with that of JPEG lossless, JPEG-2000 lossless, and JPEG-LS for medical image compression.
- Total 9 MR scans collected from the public database TCIA[1] are used as test sequences.
- Only All Intra configuration is tested, since random access to each individual slice is mandatory for medical image compression.

Sequence name	Resolution	Number of Slices	Max Bit-depth
Medical_Brain_1	512x512	22	10
Medical_Brain_2	512x512	60	9
Medical_Brain_3	512x512	60	10
Medical_Brain_4	512x512	60	9
Medical_Breast_1	864x864	84	9
Medical_Breast_2	560x560	84	9
Medical_Breast_3	640x640	90	9
Medical_Breast_4	528x528	41	10
Medical_Breast_5	672x672	60	10

Simulation Results

- Anchor: HEVC lossless (HM7.1)
- The performance of HEVC lossless coding is better than JPEG lossless, however, outperformed by JPEG-2000 lossless (14.7%) and JPEG-LS (10.8%).
- The performance of HEVC lossless coding can be significantly improved by applying the method proposed in J0230, and J0230's method outperforms the existing lossless image codec.

Sequence name	JPEG lossless	JPEG-2000 lossless	JPEG-LS	Proposed (J0230)	Proposed + SAP (J0230)	Proposed + SAP + 3 modes (J0230)
Medical_Brain_1	24.8	-15.6	-10.9	-17.4	-20.7	-19.2
Medical_Brain_2	25.7	-14.7	-10.8	-13.2	-15.8	-14.0
Medical_Brain_3	26.6	-14.5	-10.3	-11.9	-15.2	-13.5
Medical_Brain_4	26.4	-14.2	-10.0	-12.0	-14.8	-12.5
Medical_Breast_1	42.4	-19.8	-15.2	-22.9	-26.7	-26.1
Medical_Breast_2	35.3	-17.2	-13.0	-17.7	-20.4	-18.9
Medical_Breast_3	41.9	-12.5	-9.0	-13.6	-15.8	-14.6
Medical_Breast_4	23.3	-13.0	-10.3	-13.3	-14.3	-13.7
Medical_Breast_5	30.3	-10.5	-7.7	-10.3	-11.4	-10.8
Average	**30.8**	**-14.7**	**-10.8**	**-14.7**	**-17.2**	**-16.0**

Conclusion

- The medical image compression is one of the promising application areas of HEVC, since HEVC is the state-of-the-art codec which can provide the best coding efficiency.

- However, the performance of the current HEVC lossless coding is not satisfactory and even outperformed by the existing lossless image codec including JPEG-LS and JPEG-2000 lossless.

- To meet the requirements of the industry, the coding efficiency of HEVC lossless coding has to be significantly improved.

- The method proposed in JCTVC-J0230 can be one of the candidate methods for the performance improvement.

- Besides the coding efficiency, high bit-depth input (at least 16 bits for each color component), gray-scale input, etc. need to be supported for HEVC's adoption for the medical image compression.

- Considering the industry's needs, it is strongly recommended that JCT-VC make efforts for the performance improvement of HEVC lossless coding.

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THANK YOU