

Exact JPEG recompression and forensics using interval arithmetic

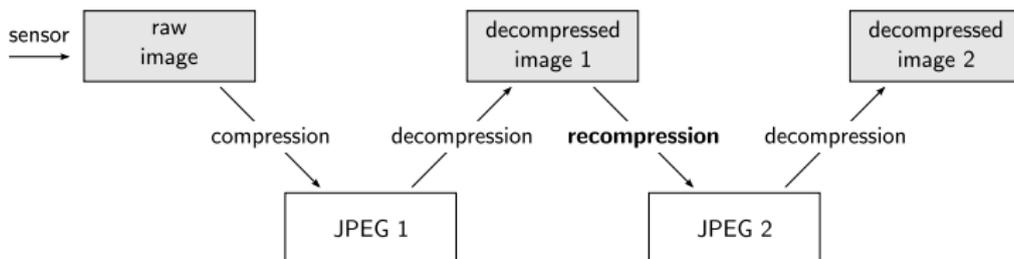
Andrew B. Lewis and Markus G. Kuhn
Computer Laboratory Security Group



UNIVERSITY OF
CAMBRIDGE

MM&Sec08 rump session

What is recompression?



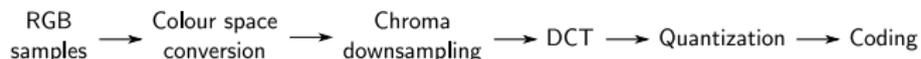
Exact recompression is useful because it allows us to

- ▶ reduce generative losses,
- ▶ characterize tampering subsequent to decompression and
- ▶ locate regions of JPEG decompressor output in an uncompressed image.

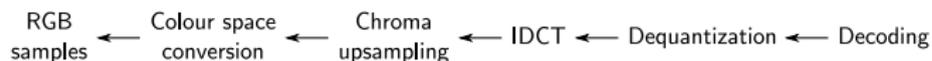
Exact recompression outputs a set of possible streams rather than a single stream.

JPEG compression and decompression

► Compression:



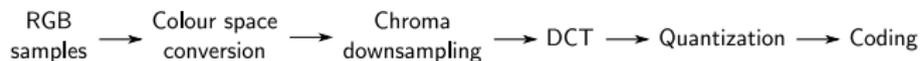
► Decompression:



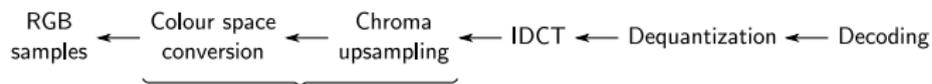
In exact recompression, we are given an uncompressed image and work back through the decompression steps keeping track of the set of possible intermediate states, ultimately determining the possible input bit-streams.

JPEG compression and decompression

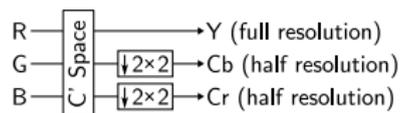
► Compression:



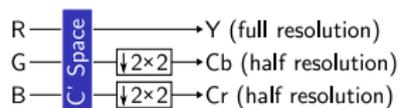
► Decompression:



We initially consider the colour space conversion and chroma up-sampling operations



Reversing colour space conversion



- ▶ During decompression, intermediate values are calculated as a function of those available from the previous decompression step.

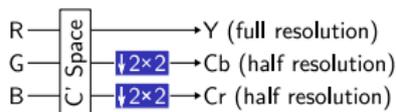
Example: YCbCr to RGB colour space conversion, inputs and outputs $I_{x,y}, O_{x,y} \in \{0, \dots, 255\}^3$ for x, y in the image.

$$O_{x,y} = f(I_{x,y})$$

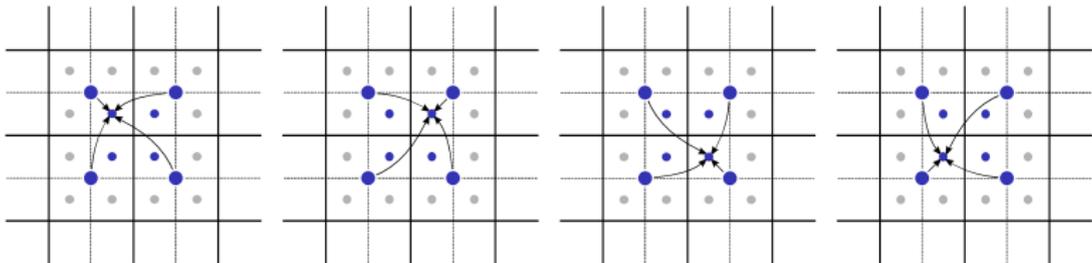
where f converts a tuple from the stored colour space to a tuple in the output colour space.

- ▶ In this example, the size of the set of possible outputs is at most 256^3 elements. To map output tuples back on to inputs, we store an inverted look-up table.

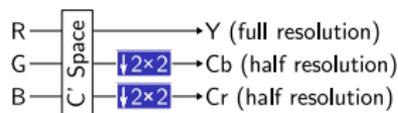
Reversing chroma up-sampling (1)



- ▶ Chroma up-sampling cannot be tackled in the same way because the set of possible outputs is huge.
- ▶ The up-sampling operation weights contributions from the four closest samples to determine an output value.



Forensic application (1)



- ▶ On images output by the decompressor, the operation converges to a fixed point.
- ▶ On images which were output by the decompressor and then tampered in uncompressed form, inconsistencies appear in the equations.
- ▶ These are output to an image to reveal the location of tampering.

Forensic application (2)

- ▶ Original



- ▶ Tampered



Forensic application (3)

- ▶ Locations of inconsistencies



- ▶ Overlay of inconsistencies with tampered image



Further work

- ▶ I am currently extending the recompressor to cover the IDCT step.
- ▶ Support other decompressor implementations
- ▶ Can this technique be applied to other types of image/video compression?
- ▶ General framework for inverting linear/overdetermined systems of equations involving information loss

Multimedia forensics bibliography

<http://www.cl.cam.ac.uk/~abl26/bibliography/main.html>