Beyond Fuzzy Hashing

Jesse Kornblum

Outline

- Introduction
- Identical Data
- Similar
- Generic Data
- Fuzzy Hashing
- Image Comparisons
- General Approach
- Documents
- Applications
- Questions

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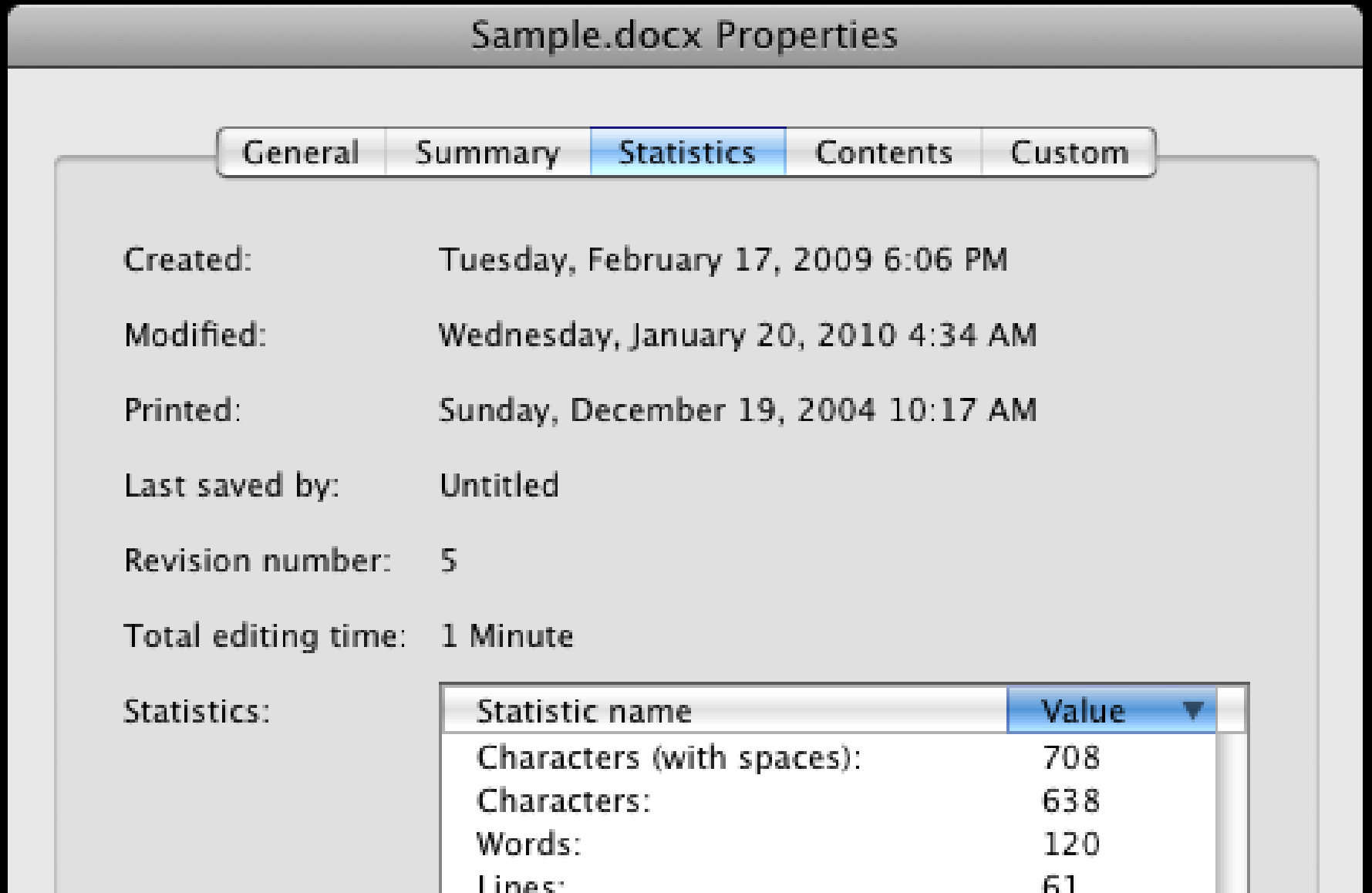
Motivation


Sample.docx Properties
General
Summary
Statistics
Contents
Custom
Created: Tuesday, February 17, 2009 6:06 PM
Modified: Wednesday, January 20, 2010 4:34 AM
Printed: Sunday, December 19, 2004 10:17 AM
Last saved by: Untitled
Revision number: 5
Total editing time: 1 Minute
Statistics:
Statistic name
Value
Characters (with spaces): 708
Characters: 638
Words: 120
Lines: 61

Identical

- A == B
- Difficult for humans (for large documents)
- Easy for computers

- Requires storing the original A and B
  - Big files
  - Could be illegal or private content

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Identical

- Cryptographic Hashing shortcut
- MD5 and friends
- If MD5(A) == MD5(B) then A == B*
  - * to within a high degree of certainty
  - Chance of random collision is 2^{-128}, or about 10^{-38}

- Hashes signatures are small
- Impossible to recover input from signature

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Identical Data

- Cryptographic hashes are spoiled by even a single byte difference in the input
- Very similar things have wildly different cryptographic hashes

Image courtesy of Flickr user krystalchu and used under Create Commons license.

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Similar Data

- What does it mean for two things to be similar?

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Similar Data

- Depends on:
  - The kind of things be compared
  - How they're being compared

- Pictures
  - Looks the same
  - Same subject
  - Same location
  - Taken by the same camera
  - Taken by the same person

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Generic Data

- Don’t care about the structure
- Assume any differences are byte aligned
  - No insertions or deletions

The quick brown fox jumped over the lazy dog. How much wood could

The quick brown fax jumped over the lazy dog. How much good could

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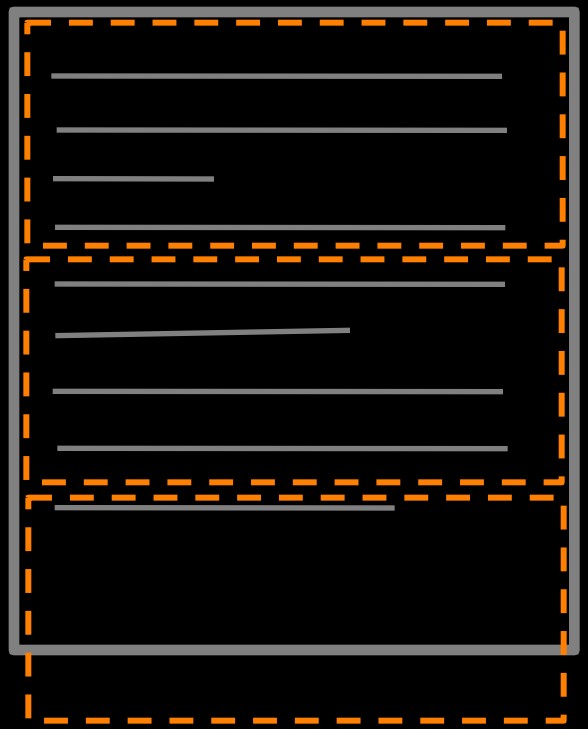
Piecewise Hashing

- Developed by Nick Harbour
  - Designed for errors in drive imaging
  - Found in dcfldd, dc3dd, md5deep, etc
- Divide input into fixed size sections and hash separately



3b152e0baa367a8038373f6df

40c39f174a8756a2c266849b

fdb05977978a8bc69ecc46ec

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Bytewise Comparison

The quick brown fox jumped over the lazy dog. How much wood could

The quick brown fax jumped over the lazy dog. How much good could

97% of the data is identical

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Bytewise Comparison

- Scenario:
  - Image computer
  - Lose control of computer
  - Regain control, image again

- 97% of the the data on the drive was identical
- What changed?

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Visual Representation

- Compare the data in each block
  - Can specify block size later
- If identical, add a green pixel
- If different, add a red pixel

The quick brown fox jumped over the lazy dog. How much wood could

The quick brown fax jumped over the lazy dog. How much good could

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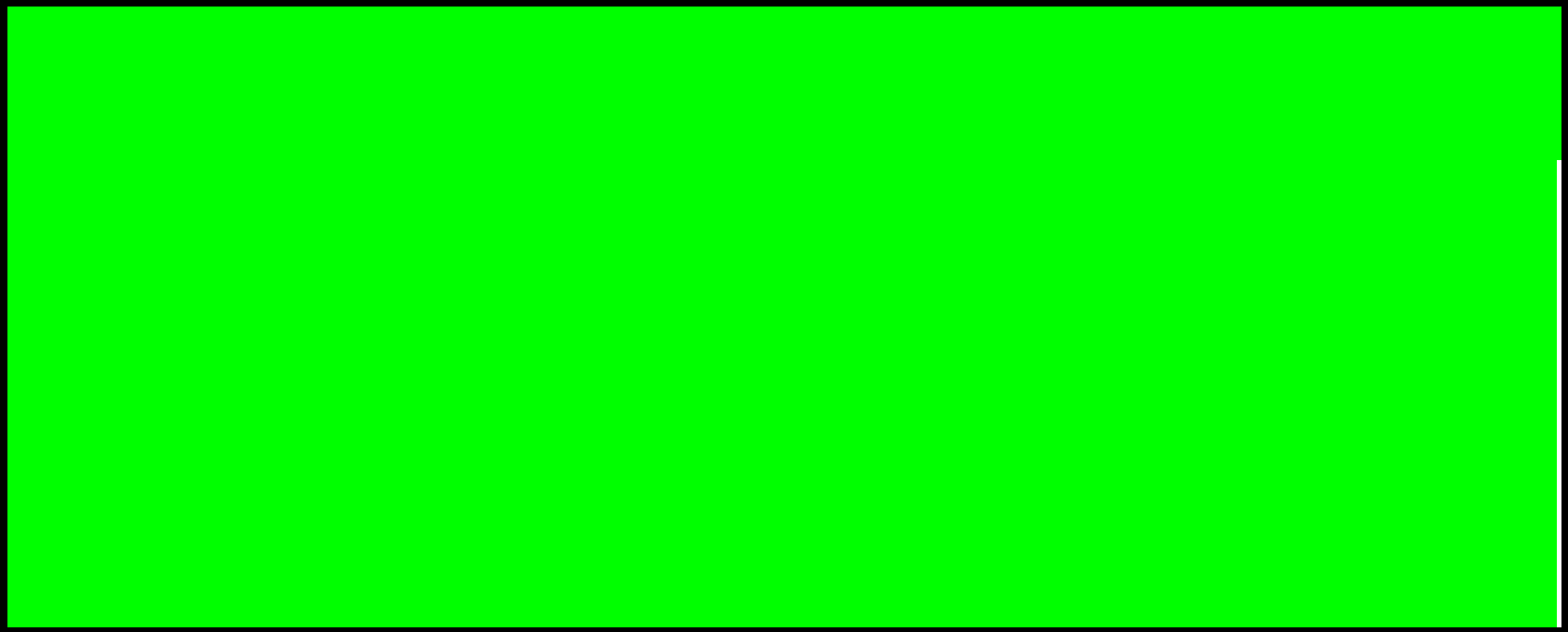
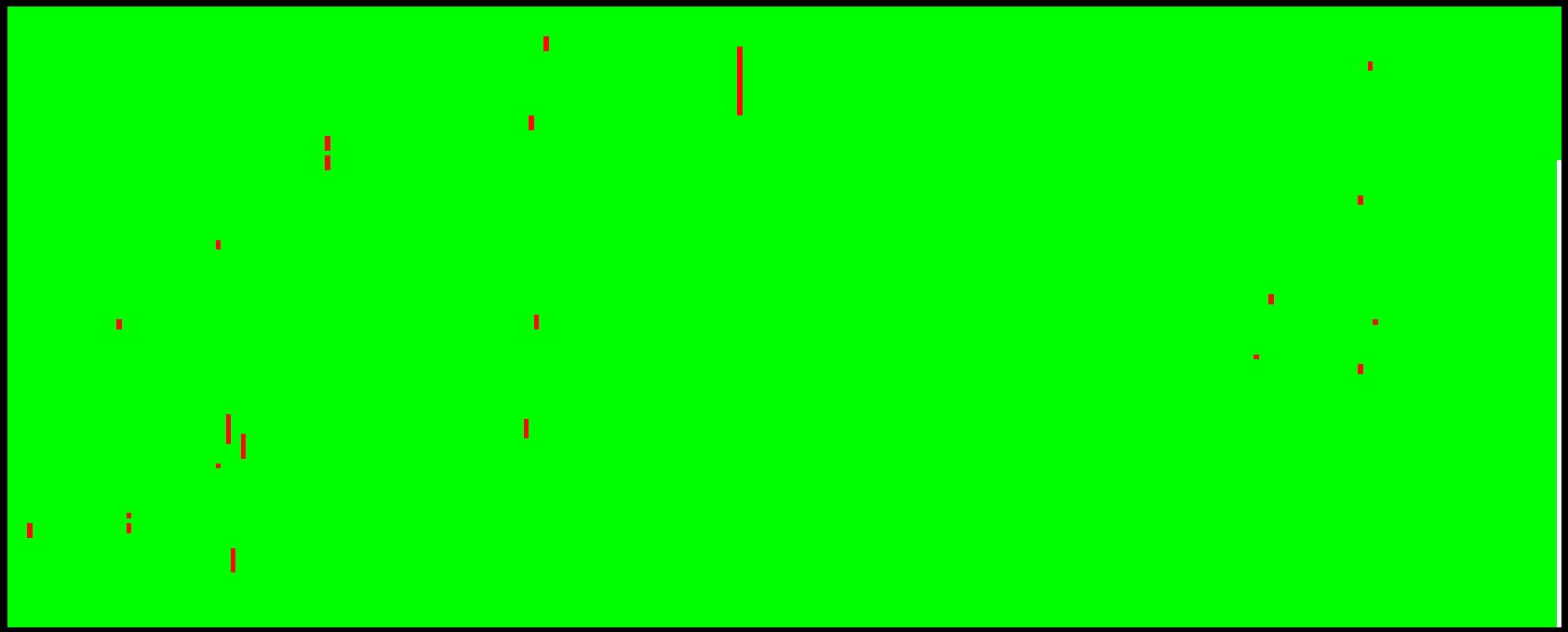
No changes made



Powered on and off



97% of the data is identical

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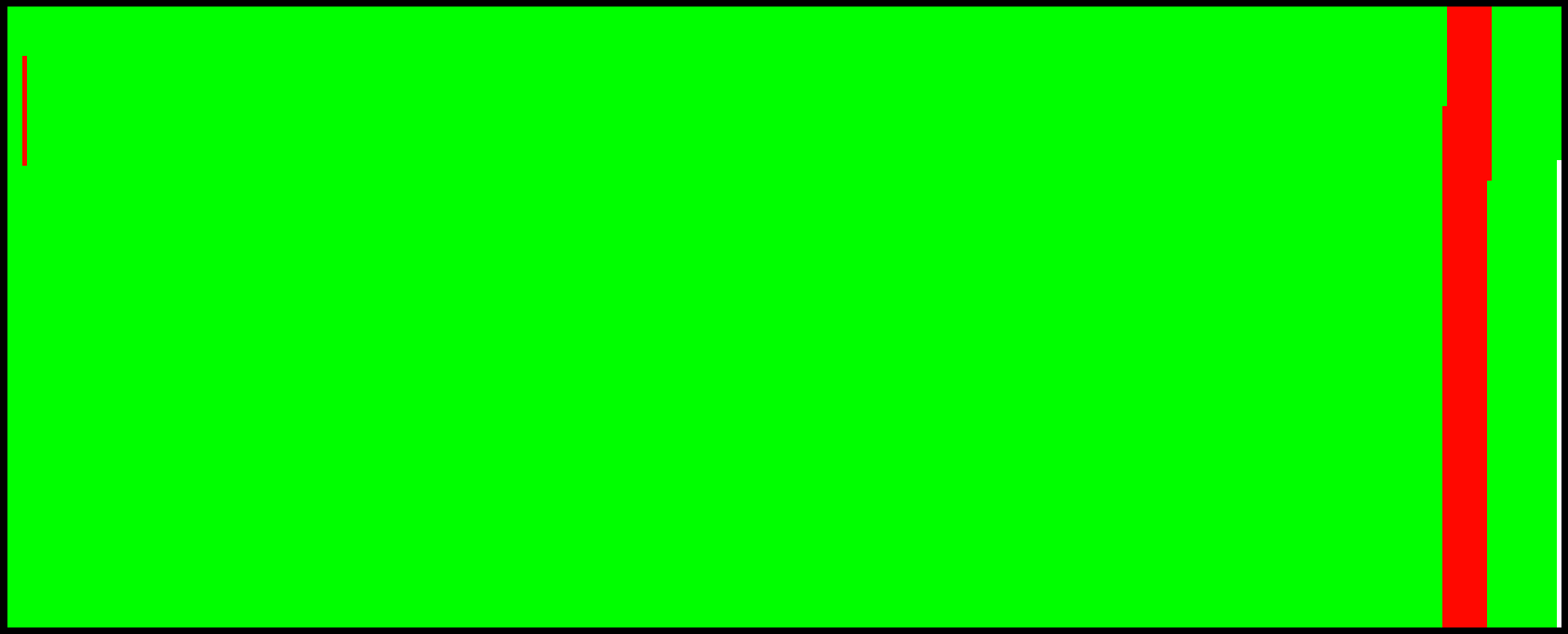
Actual Result



97% of the data is identical

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Generic Data

- What if the data is not byte-aligned?

The quick brown fox jumped over the lazy dog. How much wood could

The quick brown fox jumped up and over the lazy dog. How much wood

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Disclaimer

- I didn’t invent this math
- Originally Dr. Andrew Tridgell
  - Samba
  - rsync was part of his thesis
  - Modified slightly for spamsum
    - Spam detector in his “junk code” folder
- There is LOTS of academic research into ‘similarity’

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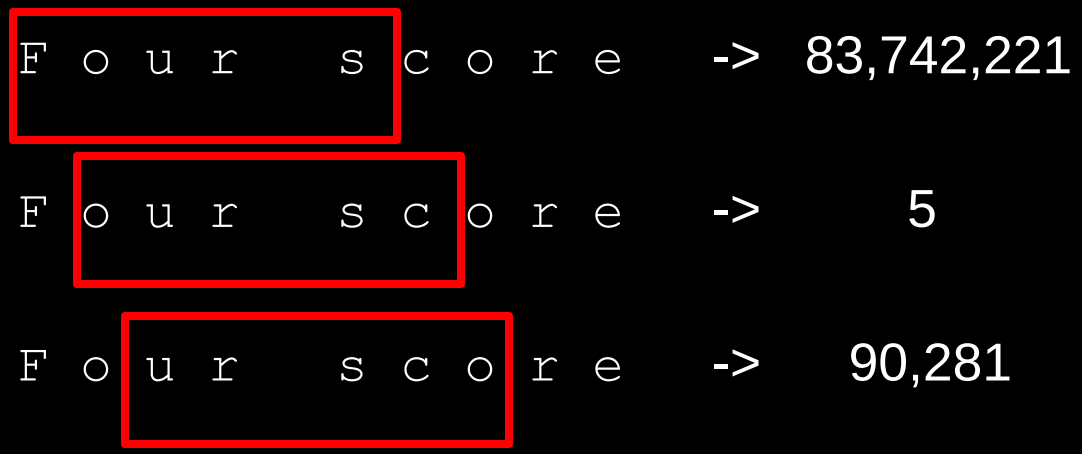
Fuzzy Hashing

- Combination of a rolling hash and traditional hash
- Rolling hash looks only at last few bytes



- If rolling hash mod block size = 1, it's a trigger point
  - Block size guessed based on file size

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Fuzzy Hashing

- Compute traditional hash while processing file
- On each trigger point, record value
- Reset traditional hash and continue

- Example
  - Excerpt from "The Raven" by Edgar Allan Poe
  - Triggers on ood and ore

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Fuzzy Hashing

Deep into the darkness peering, long I stood there, wondering, fearing
Doubting, dreaming dreams no mortals ever dared to dream before;
But the silence was unbroken, and the stillness gave no token,
And the only word there spoken was the whispered word,
Lenore?, This I whispered, and an echo murmured back the word,
"Lenore!" Merely this, and nothing more

KYRUS TECHNOLOGY

Fuzzy Hashing

Deep into the darkness peering, long I stood there, wondering, fearing
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KYRUS TECHNOLOGY

Fuzzy Hashing

Deep into the darkness peering, long I stood

there, wondering, fearing Doubting, dreaming dreams no mortals ever dared to dream before

; But the silence was unbroken, and the stillness gave no token,

And the only word there spoken was the whispered word, Lenore

?, This I whispered, and an echo murmured back the word, "Lenore

!" Merely this, and nothing more

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Fuzzy Hashing

Deep into the darkness peering, long I stood **28163**

there, wondering, fearing Doubting, dreaming dreams no mortals ever dared to dream before **491522**

; But the silence was unbroken, and the stillness gave no token,
And the only word there spoken was the whispered word, Lenore **57**

?, This I whispered, and an echo murmured back the word, "Lenore **145410213**

!" Merely this, and nothing more **738210**

KYRUS TECHNOLOGY

Fuzzy Hashing

Deep into the darkness peering, long I stood

there, wondering, fearing Doubting, dreaming dreams no mortals ever dared to dream before

; But the silence was unbroken, and the stillness gave no token,
And the only word there spoken was the whispered word, Lenore

?, This I whispered, and an echo murmured back the word, "Lenore

!" Merely this, and nothing more

Signature = 32730

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Fuzzy Hashing

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; But the silence was unbroken, and the stillness gave no token,

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?, This I whispered, and an echo murmured back the word, "Lenore

!" Merely this, and nothing more

KYRUS TECHNOLOGY

Fuzzy Hashing

Deep into the darkness peering, long I stood

there, wondering, I AM THE LIZARD KING!!!1! fearing Doubting,
dreaming dreams no mortals ever dared to dream before

; But the silence was unbroken, and the stillness gave no token,
And the only word there spoken was the whispered word, Lenore

?, This I whispered, and an echo murmured back the word, "Lenore

!" Merely this, and nothing more

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Fuzzy Hashing

Deep into the darkness peering, long I stood **28163**

there, wondering, I AM THE LIZARD KING!!!1! fearing Doubting,
dreaming dreams no mortals ever dared to dream before **381739**

; But the silence was unbroken, and the stillness gave no token,
And the only word there spoken was the whispered word, Lenore **57**

?, This I whispered, and an echo murmured back the word, "Lenore
145410213

!" Merely this, and nothing more
738210

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Fuzzy Hashing

Deep into the darkness peering, long I stood

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Original Signature = 32730
New Signatures = 39730

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Demonstration

WARNING:

EXPLICIT IMAGERY

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Demonstration

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Corrupted File

MATCH!

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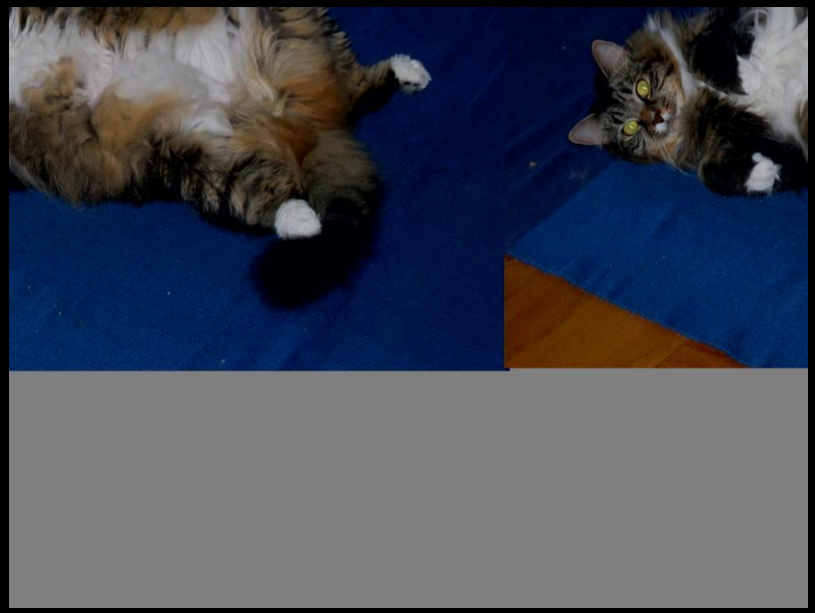
File Footer

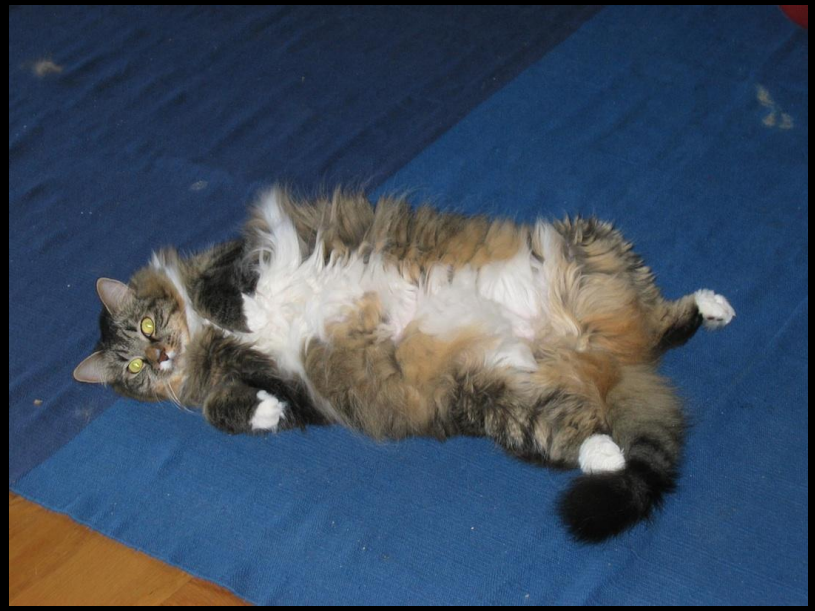
MATCH!

File Footer



MATCH!

Where Fuzzy Hashing Fails



Do not match

Comparing Pictures

- Visual Comparisons
- Easy for humans
- Somewhat difficult for computers
- Content Based Image Retrieval (CBIR)
  - There are companies tripping over themselves to do this
  - Nobody has it quite nailed yet
- A free product is ImgSeek
  - http://imgseek.net/
- Search Styles
  - Search by drawing
  - Search by example

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Search by Example

Query

Result

Image courtesy Flickr user andrewbain and licensed under the Creative Commons

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Comparing Pictures

- Non-visual comparisons
  - EXIF information
  - Same camera
    - Looks at imperfections in CCDs
    - Requires thousands of pictures and some mathy stuff

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General Approach

1. Feature Selection
2. Feature Extraction
3. Comparison
4. Clustering (optional)
5. Profit!

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Documents

- File Format Similarity
- Need to parse documents
  - Non-trivial task for complex formats
  - Development time for Word is measured in man-centuries
- Simplified parser can work in some cases
  - Ignore timestamps, for example
- OLE is a filesystem
- DOCX is a zip file of XML documents

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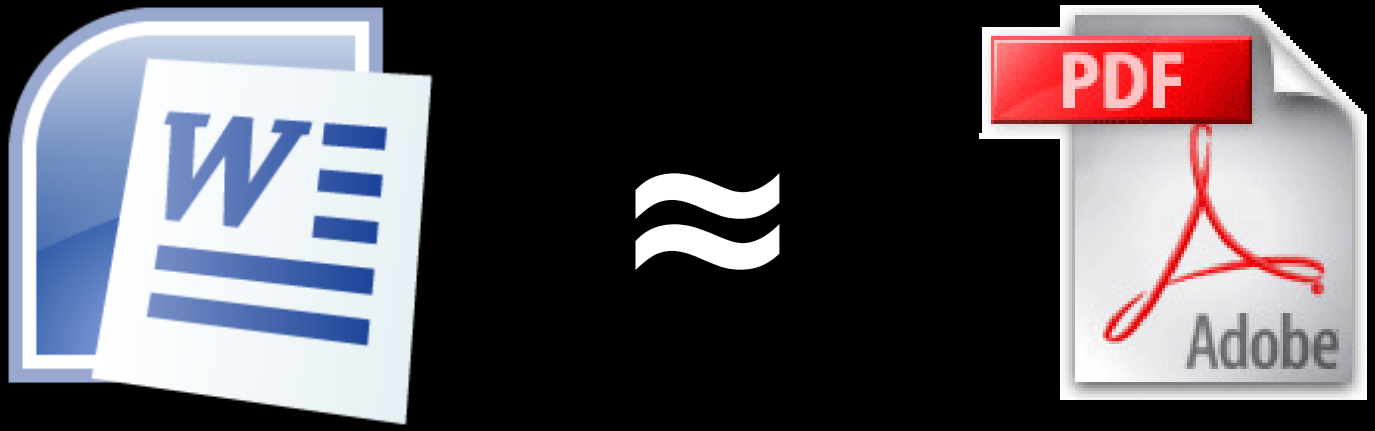
Documents

- Content similarity
  - Same document in Word and PDF formats
- Features are text



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Programs

- What makes programs similar?

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Programs

- Do the same thing
- "Look and feel"
- Same author
  - Shared libraries
  - Code reuse
- Compilation method

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Video and Music

- Generally solved
  - But costs money
- Audible Magic
  - Used by YouTube
  - Semi-scientific test at http://www.csh.rit.edu/~parallax/

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Questions?

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jesse.kornblum@kyrus-tech.com

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