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Fachbereich Sicherheit  
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# Watermarking Small Images: Applications, Challenges & Approaches

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# Outline

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- Motivation
- Challenges
- State of The Art
- Tests and Comparison of Watermarking Approaches
- Future Work
- Conclusion

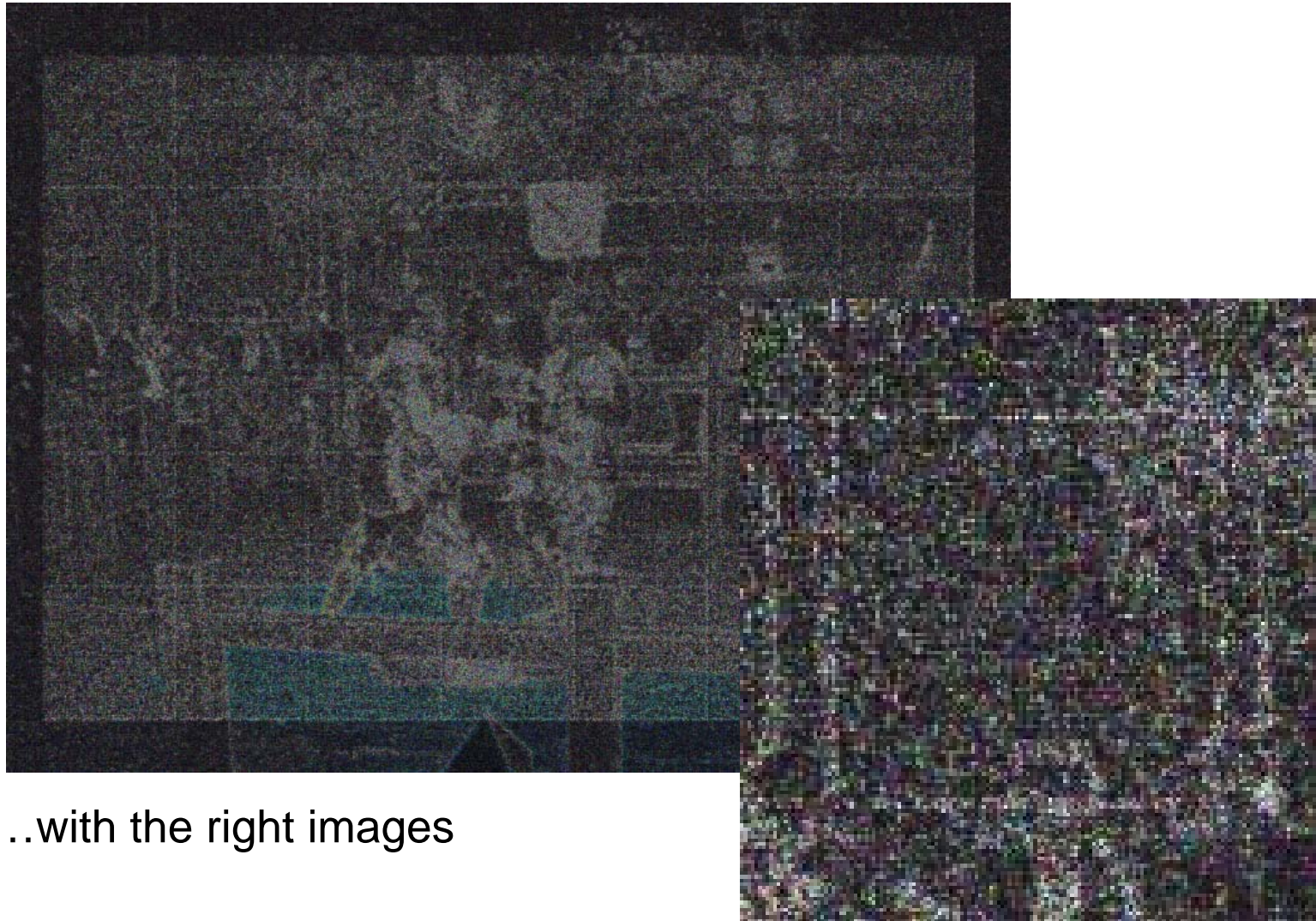
# PROLOGUE

- Image watermarking works just fine....



# PROLOGUE

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- ...with the right images

## Motivation

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- How can one identify such copyright violations?
  - Manual searching
  - Luck
  - Automatic searching
- Automatic searching would enable a certain level of protection against image theft
  - eBay has a program for taking auctions with stolen images from their site
- But how to find stolen images?
  - Direct comparison / Hashes
  - Robust hashes
  - Digital Watermarking

# Motivation

- Images are used for selling goods on the Internet
- eBay is the most prominent example for this
- Many images are “borrowed” from third party web sites

**Erscheinungsjahr:** 1999

**Sprache:** Englisch

**Zustand:** Sehr guter Zustand, wurde nur einmal gelesen und dann im Regal gelagert! Auf der Innenseite des Covers befindet s

**Porto & Verpackung:** Bei Ersteigerung von mehreren Artikeln, wird ein Versandrabatt gewährt. Bitte nachfragen!

**Achtung:** Da mein Scanner immer noch defekt ist, wurde das Artikelbild wieder nicht vom Originalartikel gemacht, sondern aus dem Netz gezogen!



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## Motivation

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## Advantages & Challenges

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- Digital watermarking has many advantages:
  - Robust against image modifications
  - Survives even media changes
    - A scan from a physical catalogue could be identified
  - Can provide more information than just the copyright info
    - Who downloaded the images
    - Where exactly did the image come from
- BUT:
  - Catalogue images are often not suited for watermarking
    - Too small
    - Too few details

## Challenges

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- Watermarking small images
  - Main concerns:
    - Watermark Capacity
    - Robustness
- Test images
  - “Pen”, “Cell phone” and “CD” size of 200x200





## Challenge

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- In the following we therefore discuss
  - Which image watermarking strategies are suited for small images?
  - What is the state of the art in image watermarking small images?
  - What can we expect in the future?



# State Of Art – Embedding Technique 1

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- Spread Spectrum Techniques
  - High robustness
    - Narrow-band watermark signal to wide-band and embedded into all the frequency bands
  - Low capacity
    - Large amount of samples to carry the wide-band signal
    - 1-bit watermarking techniques
  - Multiple embedding possible
  - High synchronization requirement
    - Extremely sensitive to geometric distortion

## Embedding Technique - 2

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- Quantization Index Modulation (QIM)
  - Moderate robustness
    - Controllable robustness to preset extent against a kind of attack, e.g. JPEG compression till particular quality factor
    - Applied quantization step determines embedding strength and robustness
  - High capacity
    - Fewer signal samples are required, e.g. block-based embedding
    - Particular features are used for embedding
  - Synchronization requirement
    - Sensitive to some geometric distortions

# Strategies against Geometric Distortions

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- Template Embedding
  - Additional information embedding
    - Reduce image quality
  - Security problem
    - Same template embedded in all copies
- Structured Watermark
  - Embedding a watermark multiple times at different spatial locations
- Embedding in Geometric Invariant Domain
  - Fourier-Mellin transform & Log-polar mapping
    - Implementation difficulties
    - Low capacity



# Watermark Algorithm Description

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- Discrete wavelet transform (DWT)
  - Embedding in the subbands of wavelet decomposition
- Spread Spectrum Watermarking
  - Watermark message: 32-bit picture ID
  - Modulated on m-sequence by the technique in [4]
  - Direct Sequence Code Division Multiple Access (DS-CDMA )
  - Additive embedding
- Adaptive local embedding strength
- Correlation-based statistical detection

# Test 1

- Test Setup
  - 1-bit watermarking
  - Embedding in the 3rd wavelet decomposition level

Images	Embedding Strength	Objective Quality (PSNR)	Subjective Quality	Detectable
Pen	Very high	44.9dB	visible artifacts	No
Cell Phone	Very high	42.7 dB	visible artifacts	No
CD	Very high	39.7 dB	visible artifacts	Yes

- When increasing the watermark payload to 32 bits, no watermark can be detected in all three test images.

## Test 2

- Test Setup
  - 32-bit watermarking
  - Embedding in the 2rd wavelet decomposition level

Images	Embedding Strength	Objective Quality (PSNR)	Subjective Quality	Detectable	Robust
Pen	Very high	39.8dB	visible artifacts	No	-
Cell Phone	Very high	38.0 dB	visible artifacts	No	-
CD	Medium	41.1dB	No visible artifacts	Yes	JPEG >85

## Tests of Strategies against Geometric Distortions

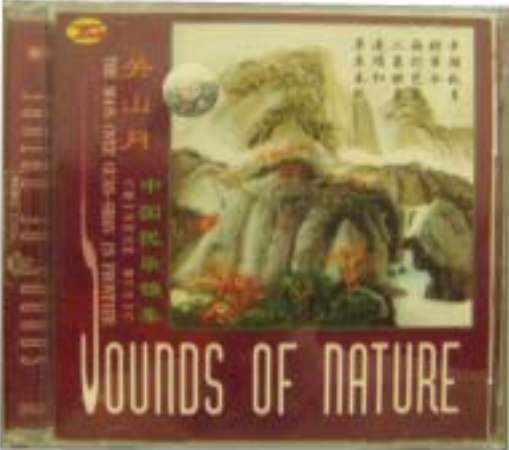
- Selected Algorithms 2
  - Template embedding in the Fourier spectrum [18]
    - Test setup
      - test images of size 200x200 pixels

Embedding Channel	Image Quality (PSNR)	Embedding position	Embedding Strength	Robustness
blue	>42dB	81° & 101°	5-20 std	JPEG >80
luminance	<35dB	81° & 101°	5-20 std	JPEG >75 Scaling >87%

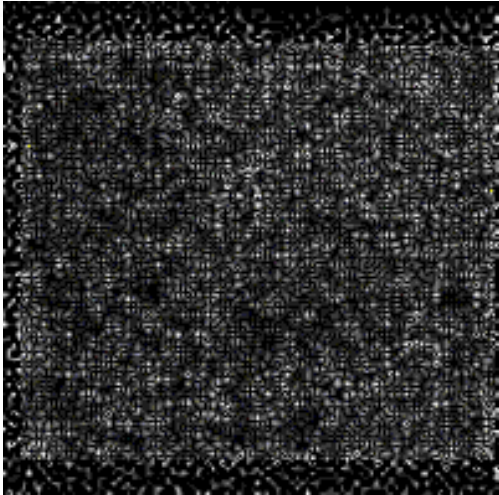
# Examples



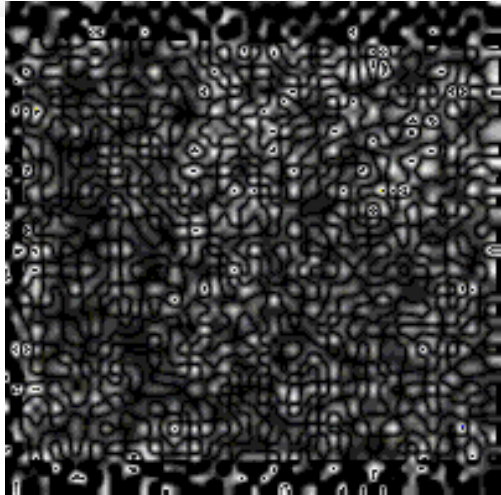
Original



Marked I2



Marked I3



# Examples



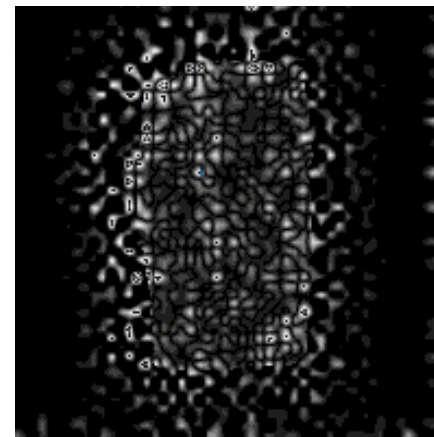
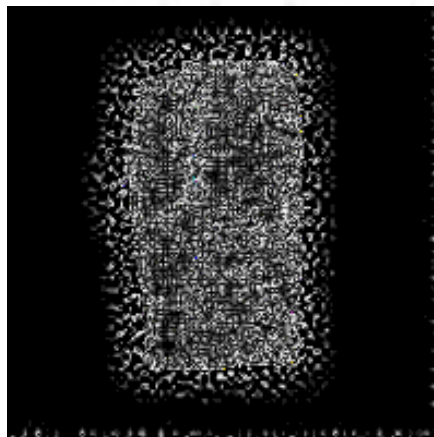
Original



Marked I2



Marked I3



# Examples

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Marked I2



Marked I3



# Examples



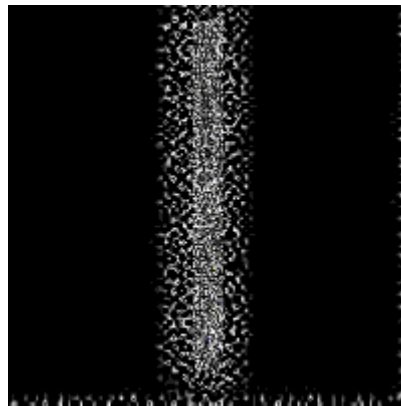
Original



Marked I2



Marked I3





## Future Work

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- Two main issues of thumbnail images
  - Reasonable watermark capacity
  - Moderate robustness
- Region of interest based watermarking scheme
  - Embed watermark only in the object, neglecting the plain background
- Embed the watermark in different scale and resolution of each image part
  - Pre-downscaling before embedding in order to improve the robustness against strong image minimizing



## Future Work

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- Other applications:
  - Watermarking of catalogue images and tracing of copyright violations of these images
  - Watermarking of business logos, small newspaper illustrations or small personal photographs
  - Small image watermarking for mobile applications, like PDA and cell phone



## Conclusion

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- Need of watermarking small images
  - Online shops, eBay
  - Other web-applications
- Challenges of watermarking small images
- Bad performance of the existing watermarking techniques when applied to small images
- Possible solutions and future work directions



## Summary

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- Watermarking small images is a special challenge
- There is insufficient pixel space to use common strategies
- Embedding a small number of bits is possible
- Adjusted strategies are required for small images

# Thank you

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- Questions ?



## Tests of Strategies against Geometric Distortions

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- Selected Algorithms 1
  - Embedding in geometric-transform-invariant Fourier-Mellin domain [4]
  - Results
    - almost impossible to extract the watermark correctly while keeping the watermarked image's quality acceptable

## Result Analysis

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- Reasons for the weak performance
  - Small image size
    - Limited amount of samples of host signal
    - Limited length of spread spectrum sequence
  - Plain background
    - Characteristics of web images, pure color background in most cases.
    - Low embedding strength, easy to introduce artifacts
    - Watermark is easily erasable.
  - Due to the extreme uneven watermark capacity, block-based QIM watermarking in DCT or DWT does not work well either.