
بسم الله الرحمن الرحيم

COMPRESSION BASED ON COMPRESSIVE SENSING

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CONTENTS

1. WHAT?
   - Introduction to Compressed Sensing (CS)

2. HOW?
   - Theory behind CS

3. FOR WHAT PURPOSE?
   - CS applications

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1. **WHAT?**
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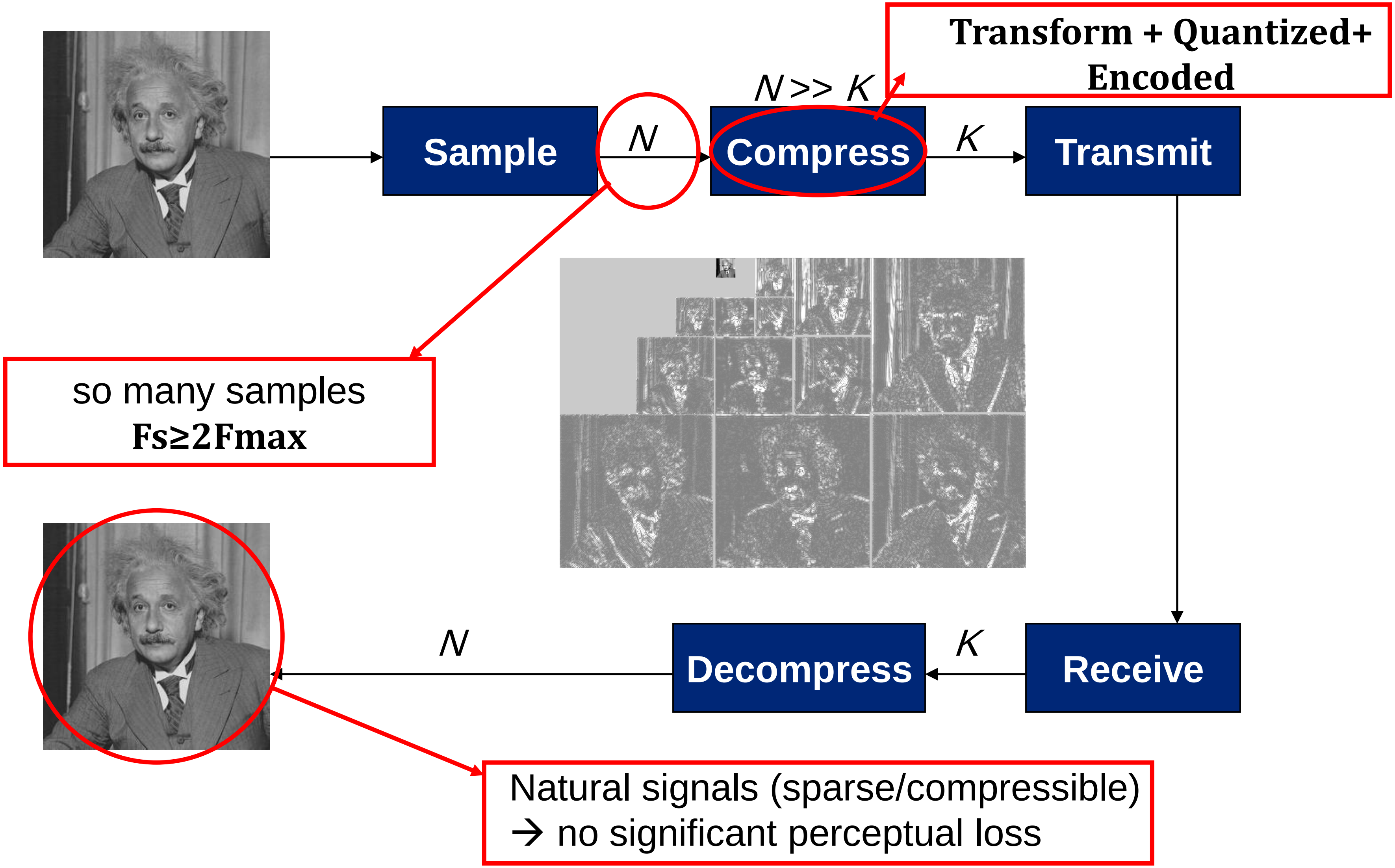
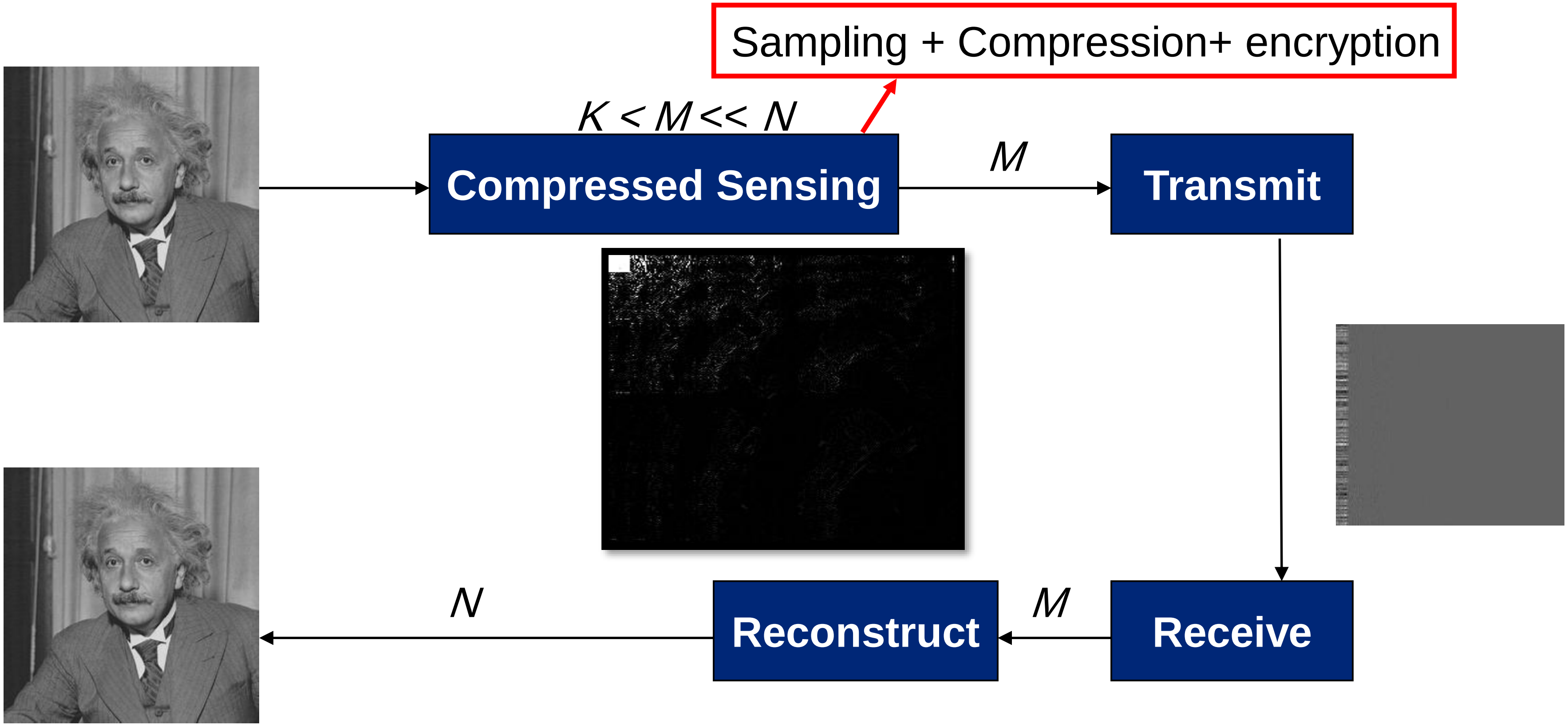
Shannon/Nyquist theorem



Compressed Sensing (CS)



- ***COMPRESSIVE SENSING:-*** **is new method to capture and represent sparse/compressible signals at the rate well below Nyquist's rate.**

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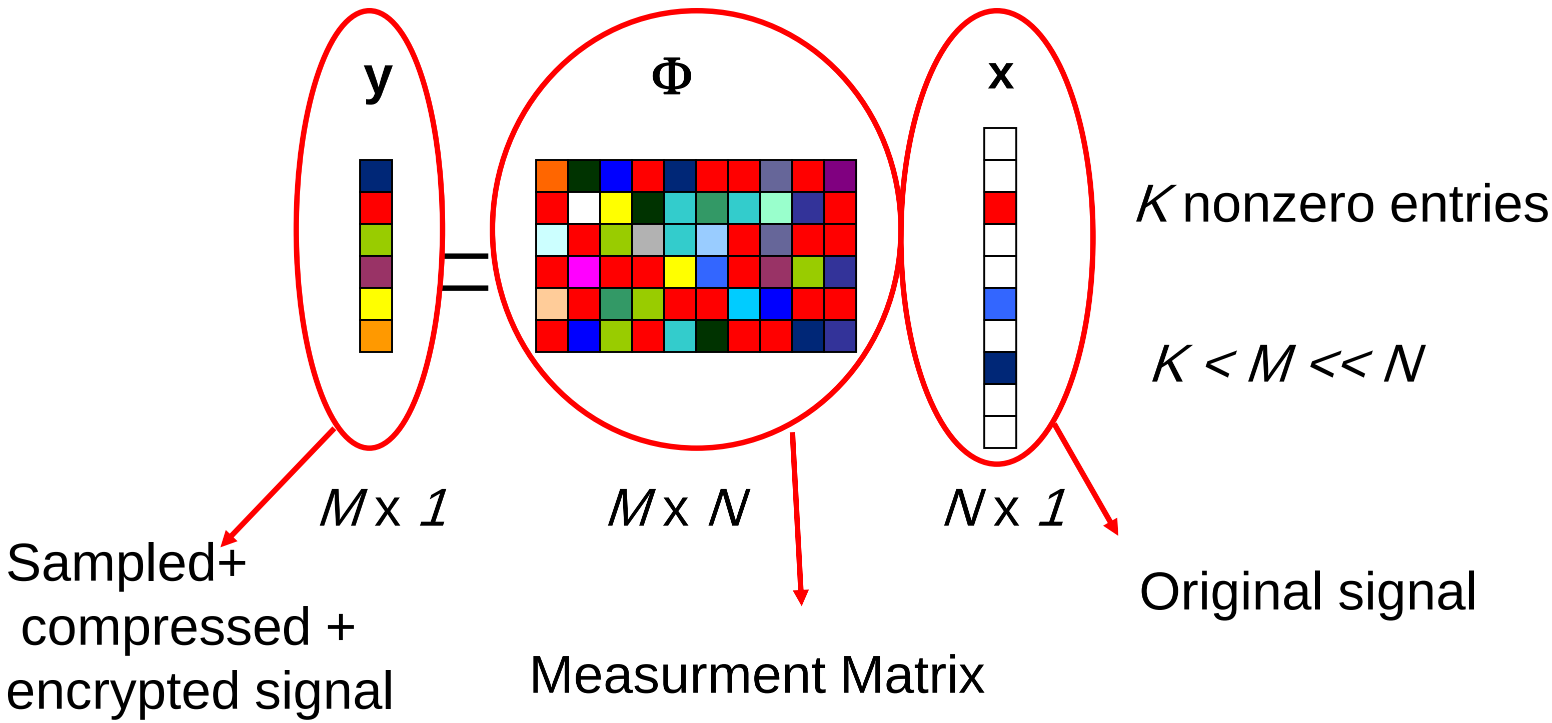
CS consists of two parts:-

1- SAMPLING (ENCODING)

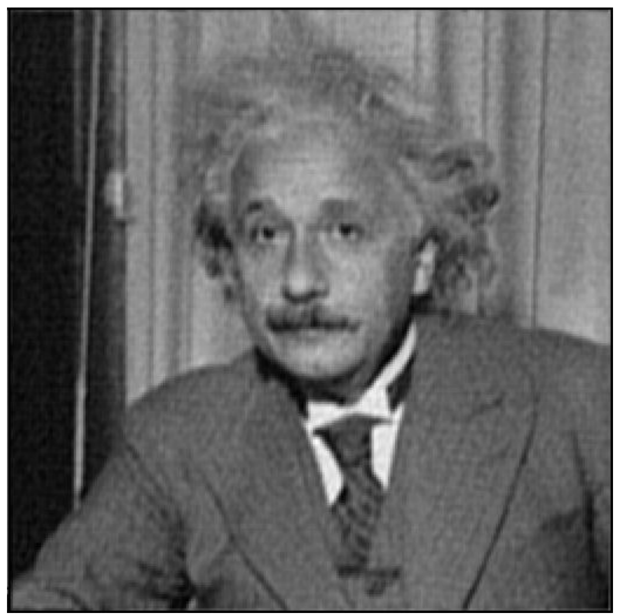
- When the signal is sparse/compressible, we can directly acquire a condensed representation with no/little information loss



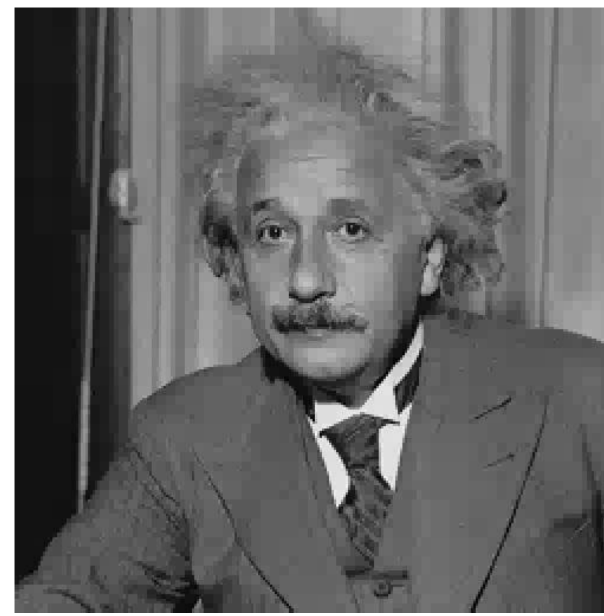
Sparseness: less is more

- Pixels: not sparse ☹
- A new domain can increase sparseness ☺

Original *Einstein*
Taking 10% pixels



10% Fourier coeffs.

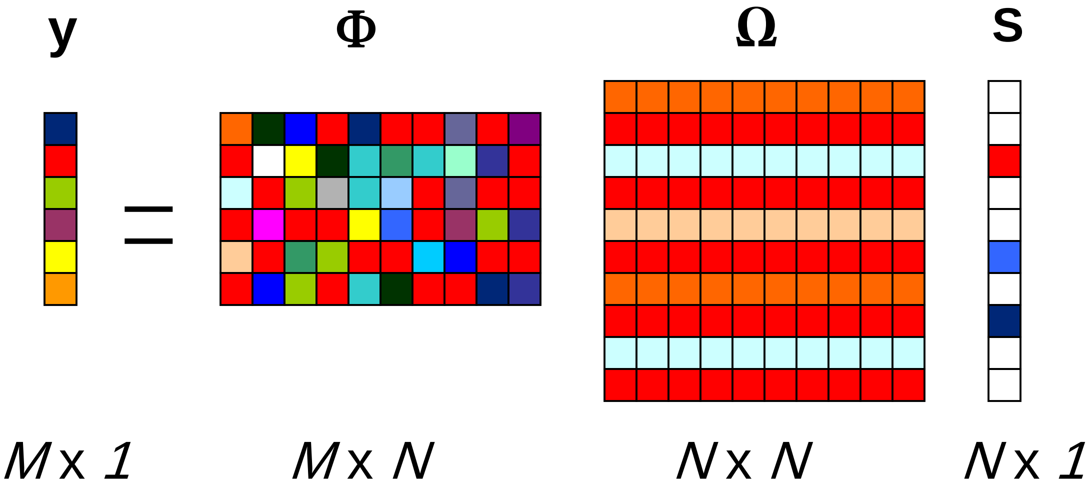


10% *Wavelet* coeffs.

Universality

- Random measurements can be used if signal is sparse/compressible in any basis

$$Y = \phi X = \phi \Omega S = \theta S$$



K nonzero entries

$K < M << N$

θ = Compressive sensing Matrix

2- RECOVERY (DENCODING)

- Minimization of *L*1-norm
- Greedy techniques
- Iterative thresholding
- Total-variation minimization
- …

How It Works

1) Undersample

A camera or other device captures only a small, randomly chosen fraction of the pixels that normally comprise a particular image. This saves time and space.

How It Works

2) Fill in the dots

An algorithm called l_1 minimization starts by arbitrarily picking one of the effectively infinite number of ways to fill in all the missing pixels.

How It Works

3) Add shapes

The algorithm then begins to modify the picture in stages by laying colored shapes over the randomly selected image. The goal is to seek sparcity, a measure of image simplicity.

How It Works

4) Add smaller shapes

The algorithm inserts the smallest number of shapes, of the simplest kind, that match the original pixels. If it sees four adjacent green pixels, it may add a green rectangle there.

How It Works

5) Achieve clarity

Iteration after iteration, the algorithm adds smaller and smaller shapes, always seeking sparsity. Eventually it creates an image that will almost certainly be a near-perfect facsimile of a hi-res one.

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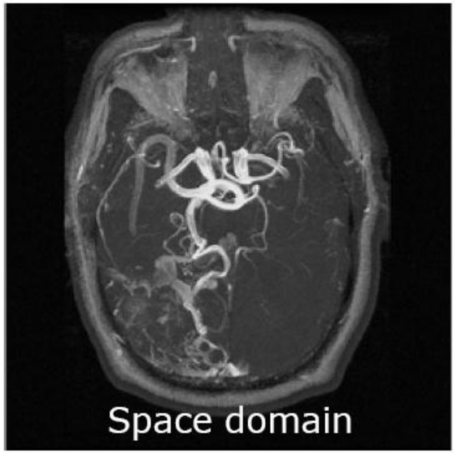
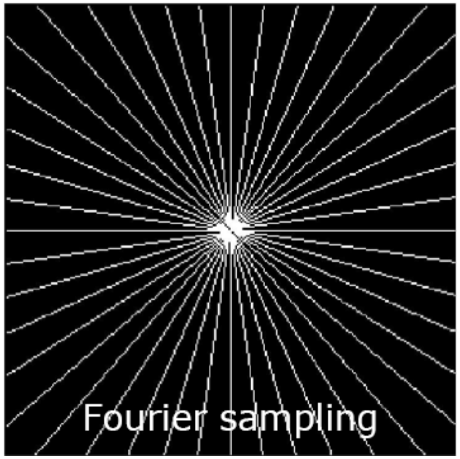
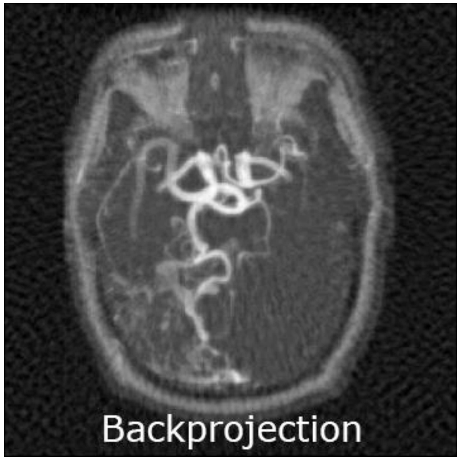
Some CS applications

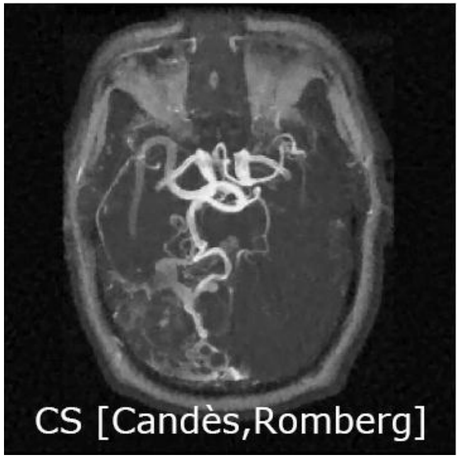
- Data compression
- Compressive imaging
- Detection, classification, estimation, learning…
- Medical imaging
- Analog-to-information conversion
- Geophysical data analysis
- Hyperspectral imaging
- Compressive radar
- Astronomy
- Communications
- Surface metrology
- Spectrum analysis
- …

Magnetic resonance imaging

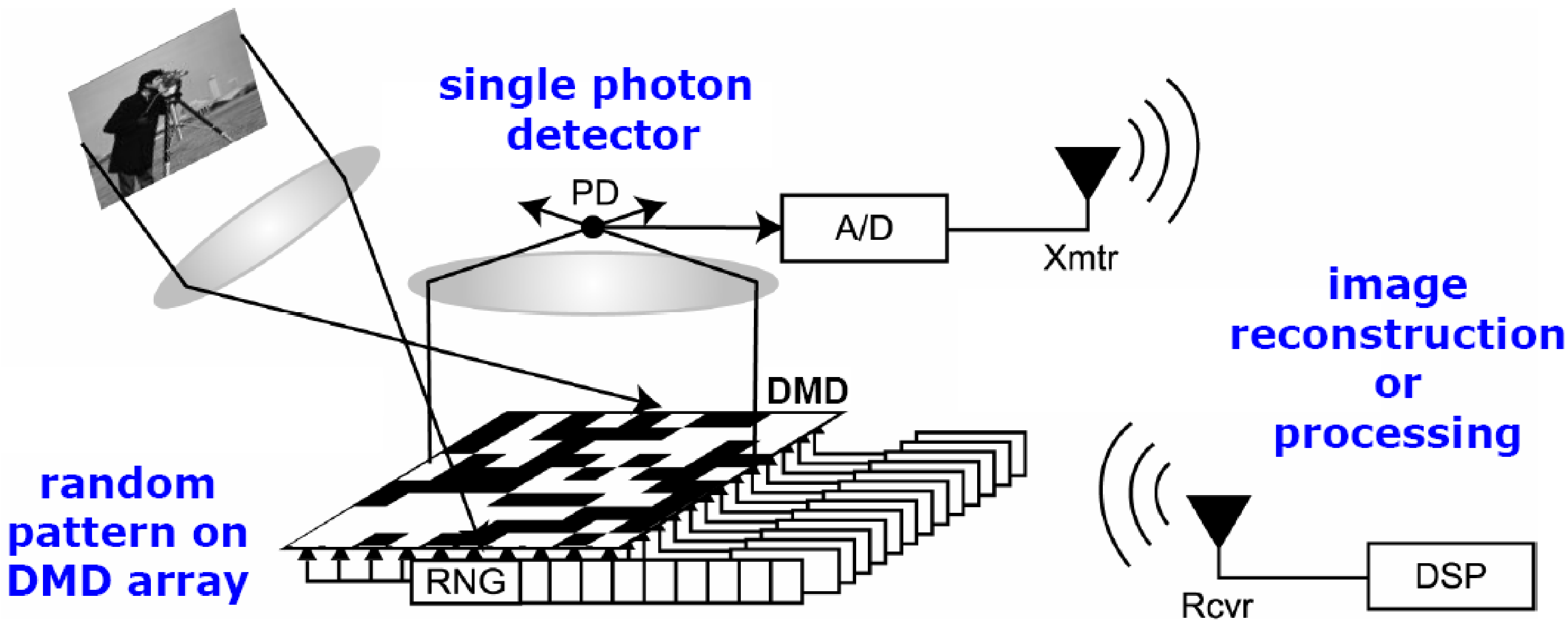








Rice Single-Pixel CS Camera



Conclusions

- CS is a new technique for acquiring/ sensing and compressing Data simultaneously
- Sparseness + Incoherence + random sampling allows perfect reconstruction under some conditions
- A wide range of applications are possible
- Big research effort now on recovery techniques

Thank you