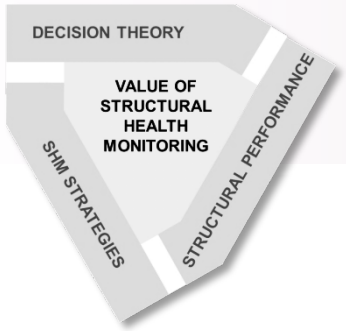

Application of distributed optical fiber sensor technology for strain measurements in concrete structures

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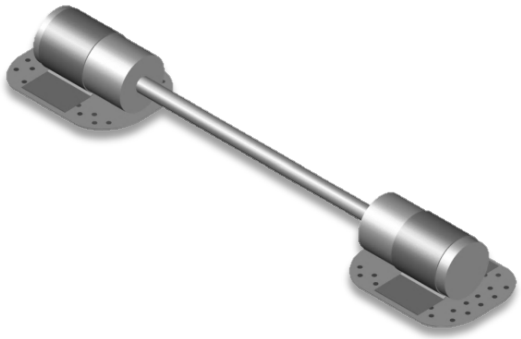
Structural Health Monitoring Systems

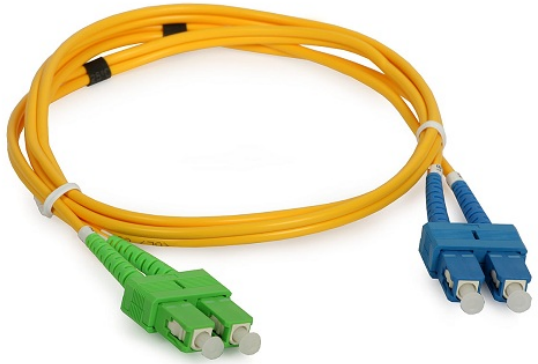
Today

spot measurements



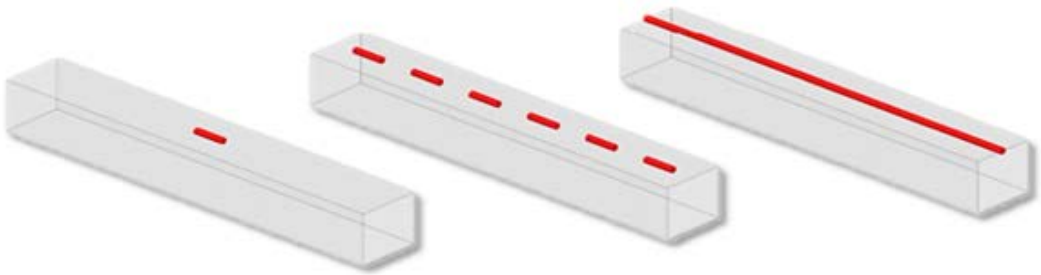
Tomorrow

distrbuted measurements



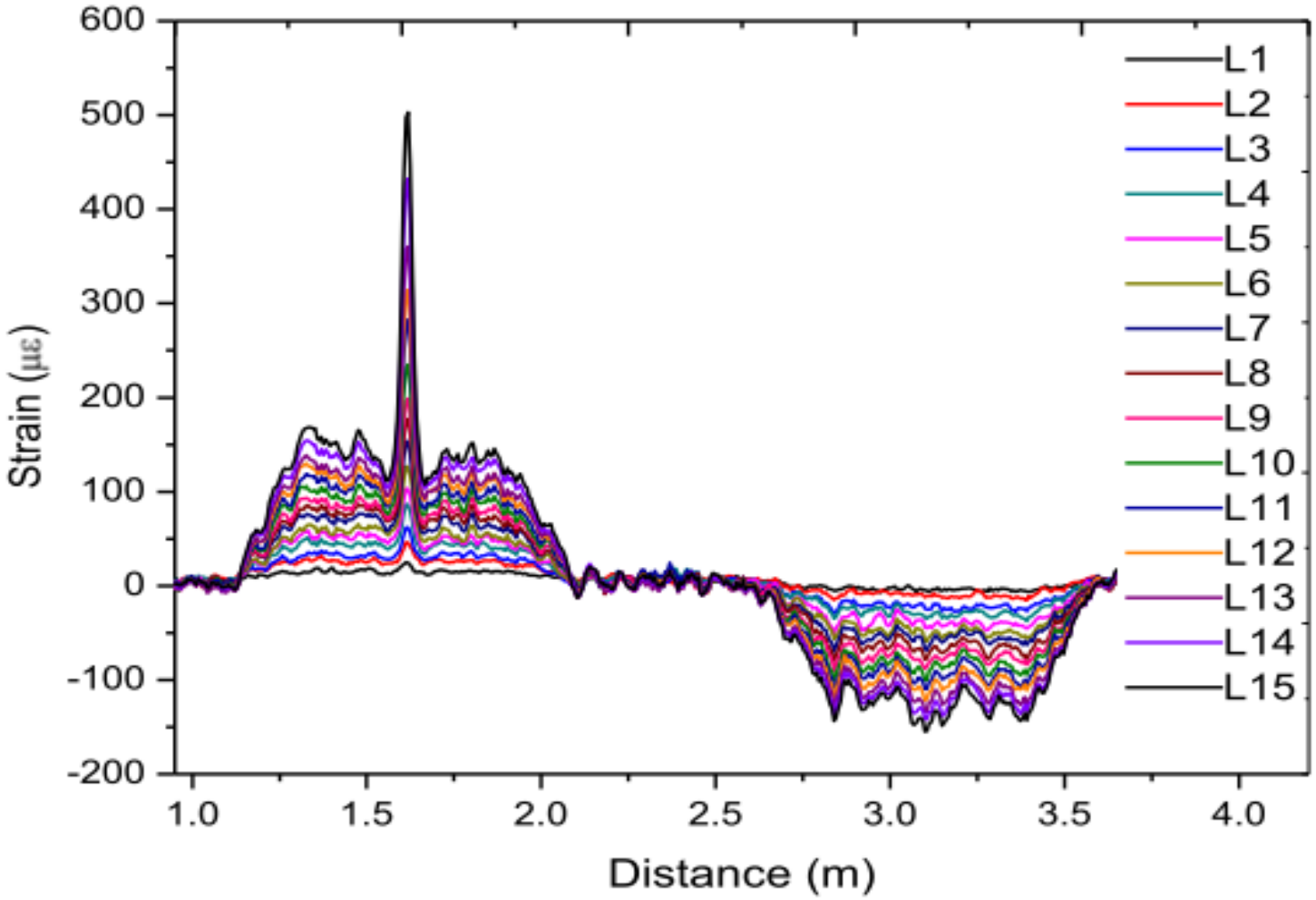
- Bragg gratings, Fabry – Perot interferometers
- Rayleigh, Raman or Brillouin scattering

Measurement = f (t, L)



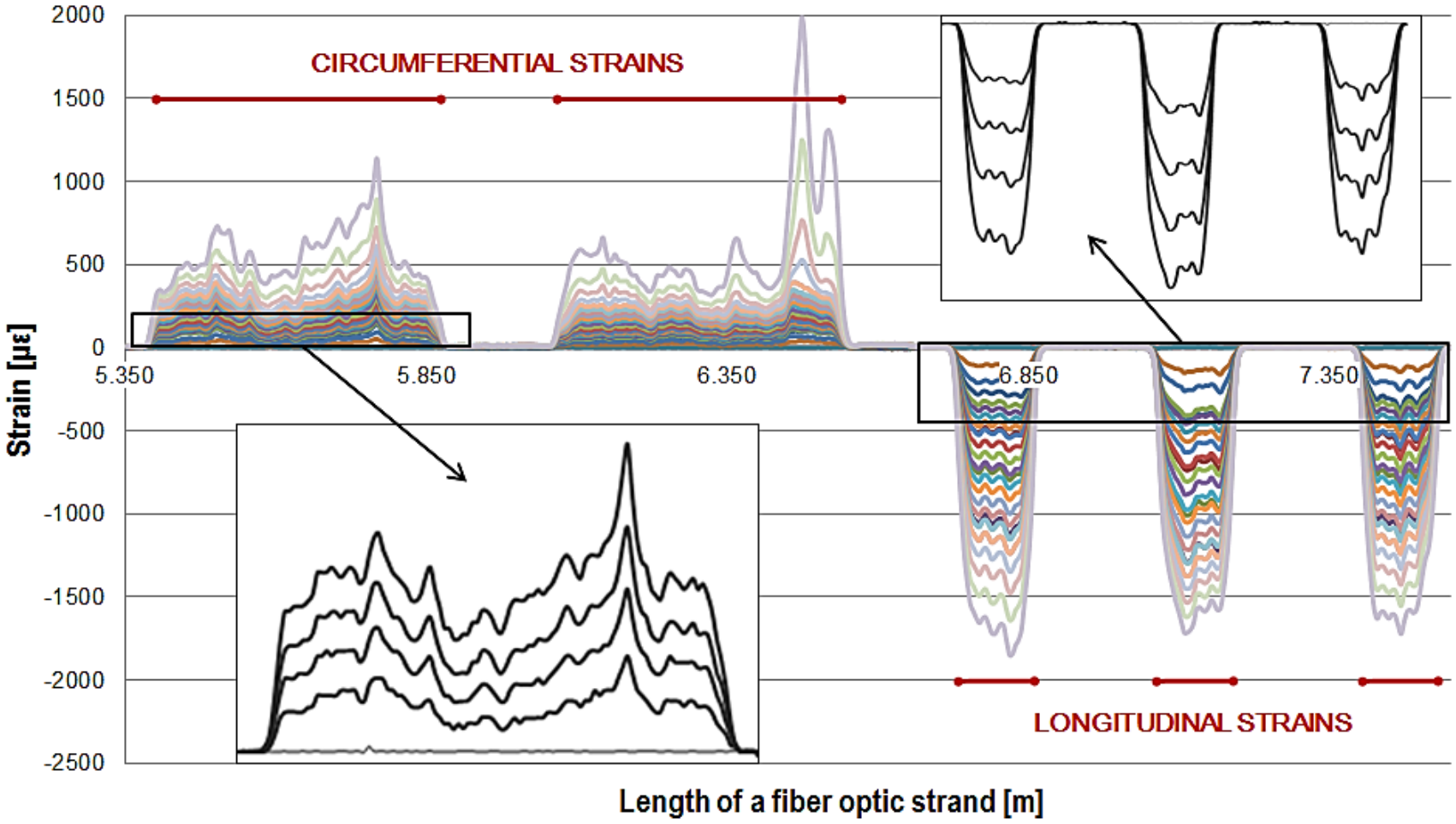
Li W., Bao X., 2013

- reinforced concrete beams
- four-point bending
- embedded strands and glued to surfaces
- trapezoidal strain distribution
- crack detection
- shape kept durng load stages

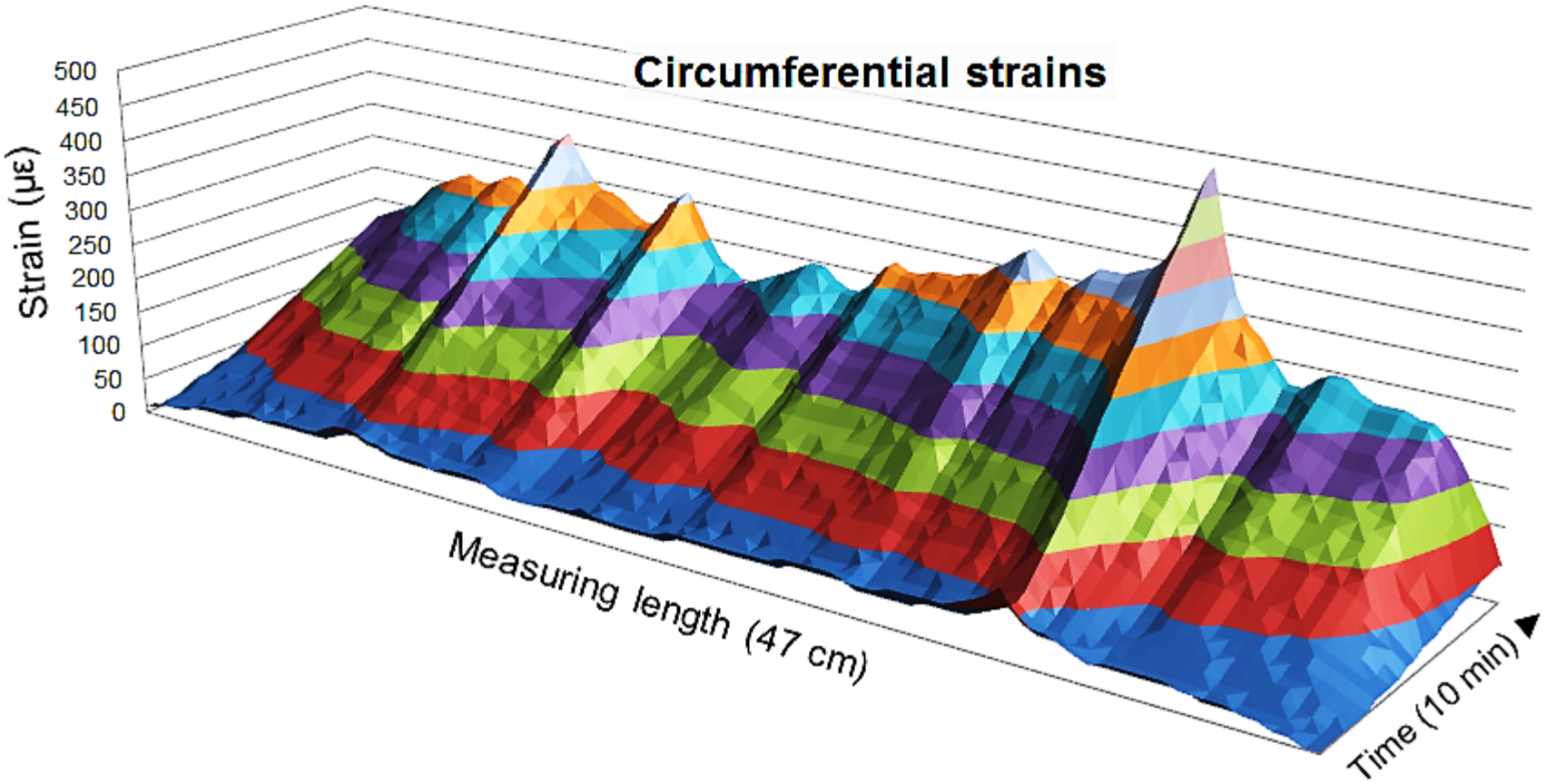

600
500
400
300
200
100
0
-100
-200
Strain (με)
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Distance (m)
L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
L11
L12
L13
L14
L15

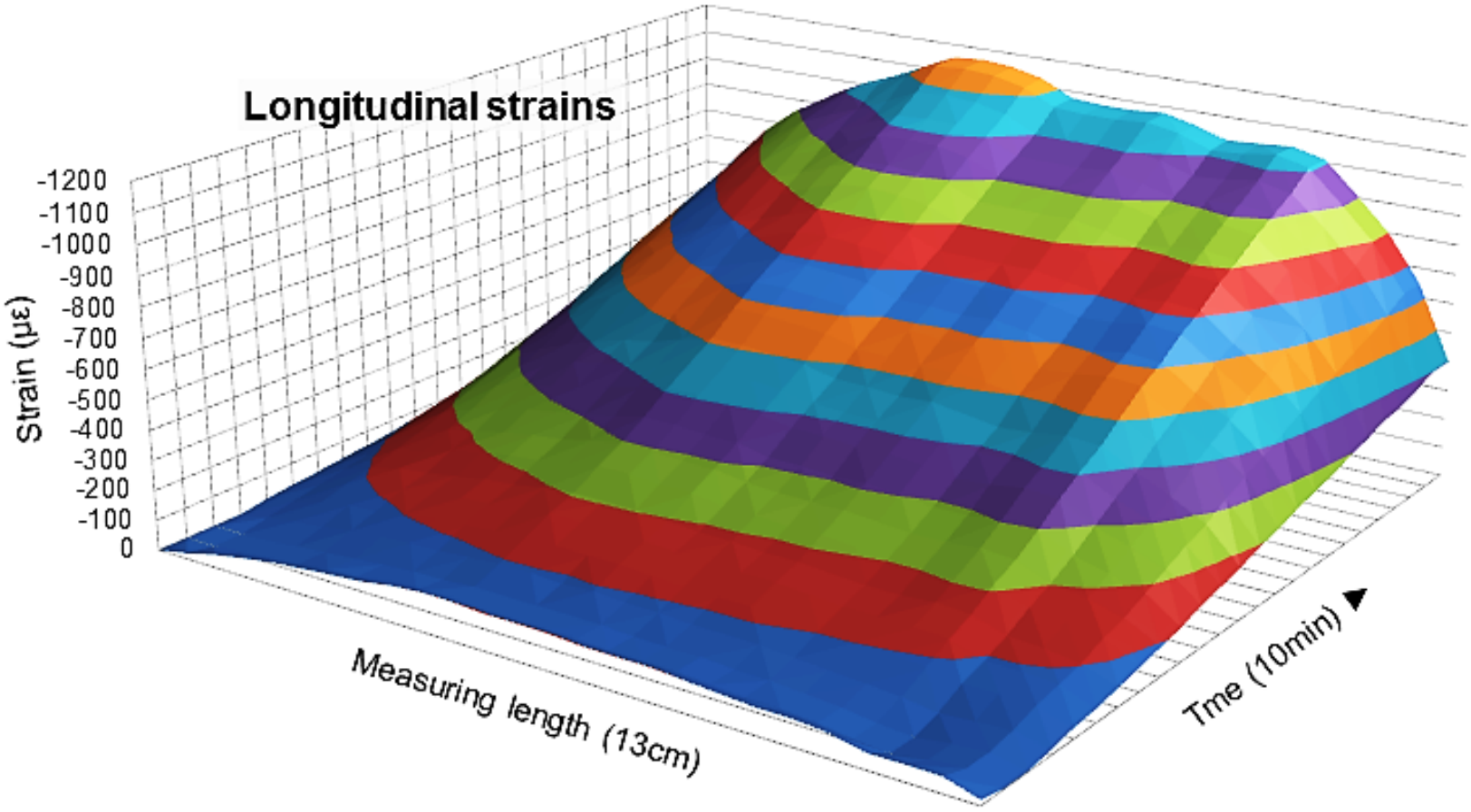
COMPRESSED SAMPLE

- sample 300 x 150 mm
- 5 measurement sections
  - 3 longitudinal (130 mm)
  - 2 circumferential (470 mm)
- sensor base: 5 mm
- external extensometers
- two stages
  (to 40 MPa and until
  destruction)
- zero reading


CIRCUMFERENTIAL STRAINS
LONGITUDINAL STRAINS
Strain [με]
Length of a fiber optic strand [m]
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
5.350
5.850
6.350
6.850
7.350

Results


Circumferential strains
Strain (με)
500
450
400
350
300
250
200
150
100
50
0
Measuring length (47 cm)
Time (10 min)


Longitudinal strains
Strain (με)
-1200
-1100
-1000
-900
-800
-700
-600
-500
-400
-300
-200
-100
0
Measuring length (13cm)
Tme (10min)

Variation coefficient of strain distribution:

$$V = \frac{s_\varepsilon}{\varepsilon_{śr}} = \frac{n \cdot \sqrt{\frac{\sum_{i=1}^{n}(\varepsilon_i - \varepsilon_{śr})^2}{n-1}}}{\sum_{i=1}^{n} \varepsilon_i}$$

Longitudinal: **36%**

Circumferential: **45%**

where:

s_ε – standard deviation of the strain distribution ,

$\varepsilon_{śr}$ – averaged strains along the section,

ε_i – subsequent strain values along the section,

n – number of measurements along the section.

Challenges

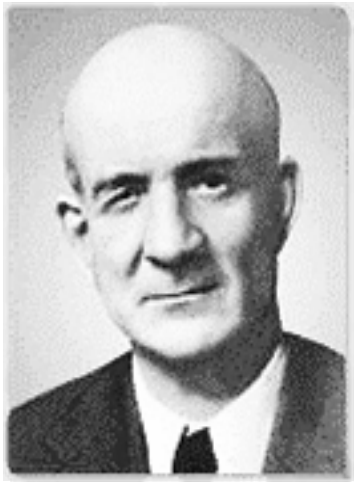
- computational algorithms → crack width
- accuracy and range
- strand mounting modes → material
- “transmission” length
- compensation for thermal influences
- remote and automatic execution of measurements
- simultaneous read out of several fiber optic strands
- correlation between the longitudinal and transverse strains

Possible advantages

- early warning about abnormalities
- damage detection
- crack monitoring in RCS (durability)
- monitoring of engineering structures, pipelines, dams ets.
- distributed strain and temperature measurements
- reducing costs in SHM Systems
- development of science

The only true model of
body's elasticity,
is this body...

prof. Zbigniew Wasiutyński



Theory + Practice

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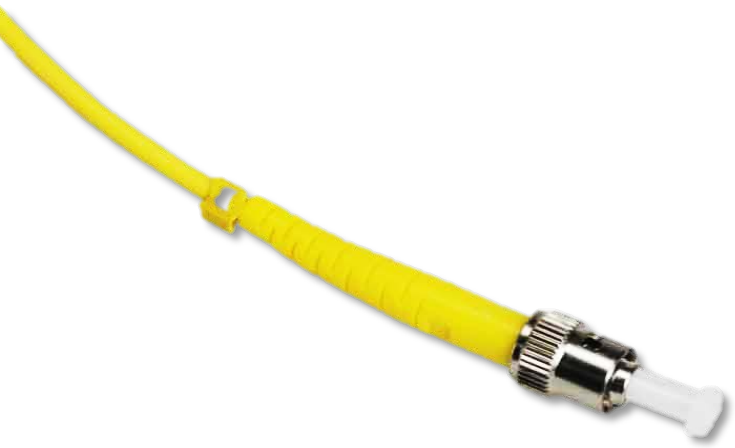

Thank You

for your attention :)