MERENJA U HIDROTEHNICI

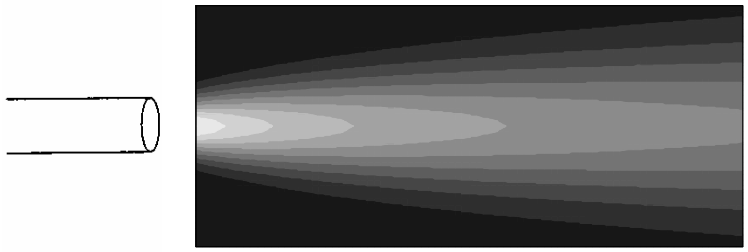
Šta je to PIV?

Vežba 7

Zašto koristiti fotografisanje?

Konvencionalne metode
(Topla žica, LDA)

- **Merenje u jednoj tački**
- **Remete tok**
- **Zahtevaju određeno vreme**
- **Dobijamo samo statističke parametre brzo promenljivih pojava**



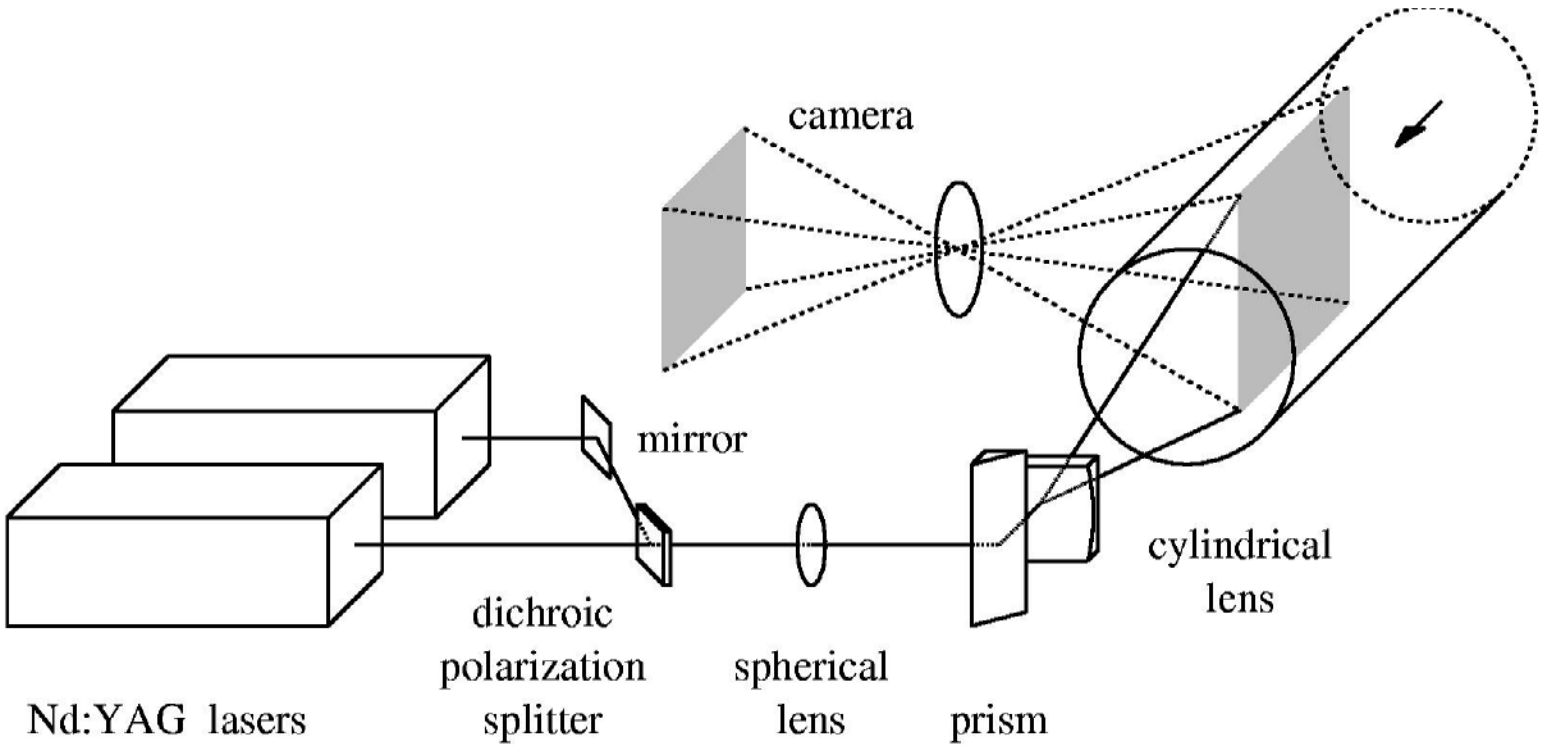
Particle Image Velocimetry

- **Zahvata celo strujno polje**
- **Neinvazivno**
- **Trenutno**

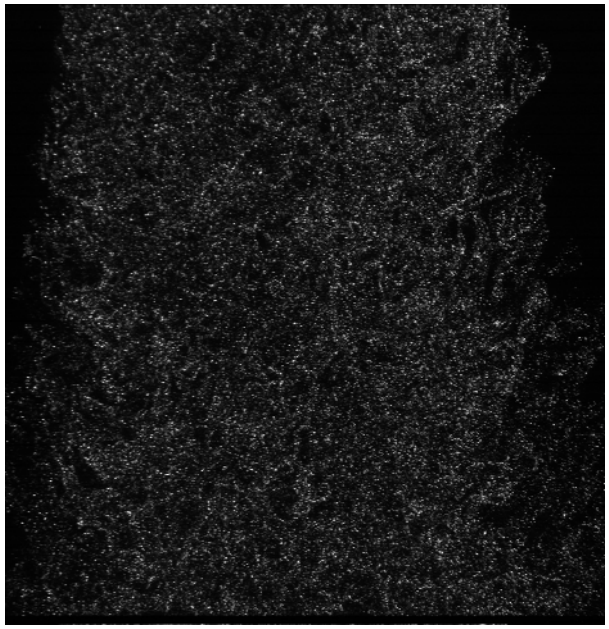
Suština PIV tehnike

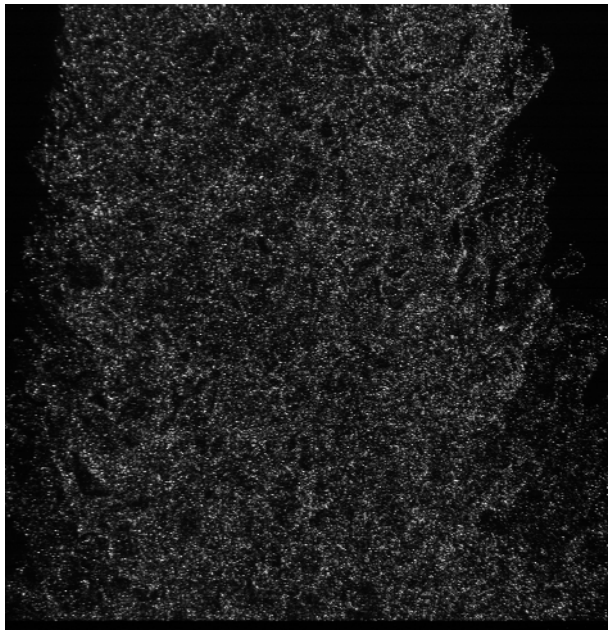
- **Zasejavanje struje malim traserima koji se kreću zajedno sa tokom fluida**
- **Osvetljava se poprečni presek koji se ispituje laserskom svetlošću**
- **Slika se poprečni presek, sa rezolucijom koja nam omogućava da vidimo trasere, dva puta u susednim vremenskim trenucima**
- **Delimo slike na polja za ispitivanje i principom kroskorelacije za svako polje određujemo vektor brzine**
- **Uklanjanje pogrešnih i vektora i buke**
- **Postprocesiranje (računanje veličina koje nas interesuju)**

PIV optička konfiguracija

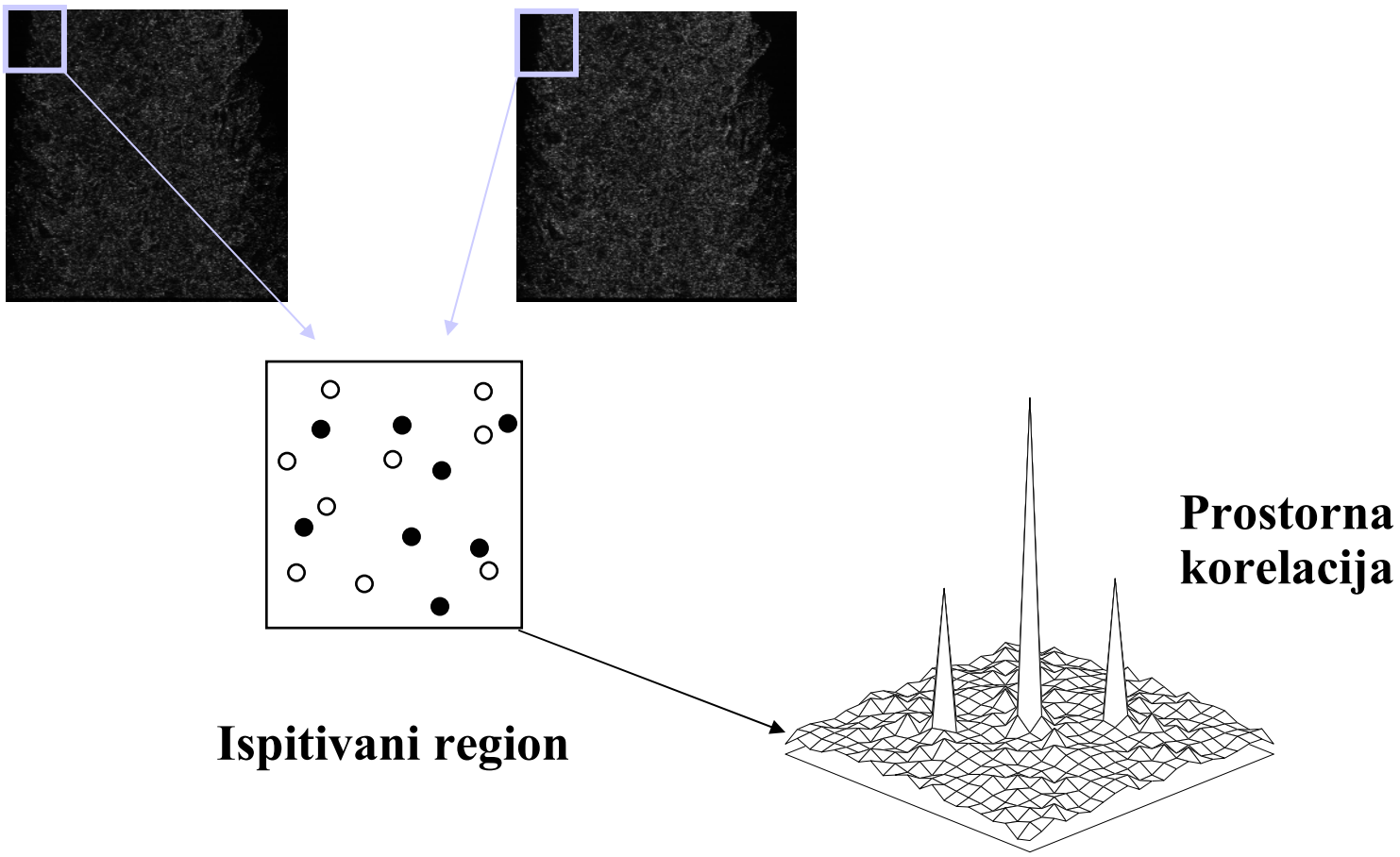


Slike u dva susedna vremenska trenutka

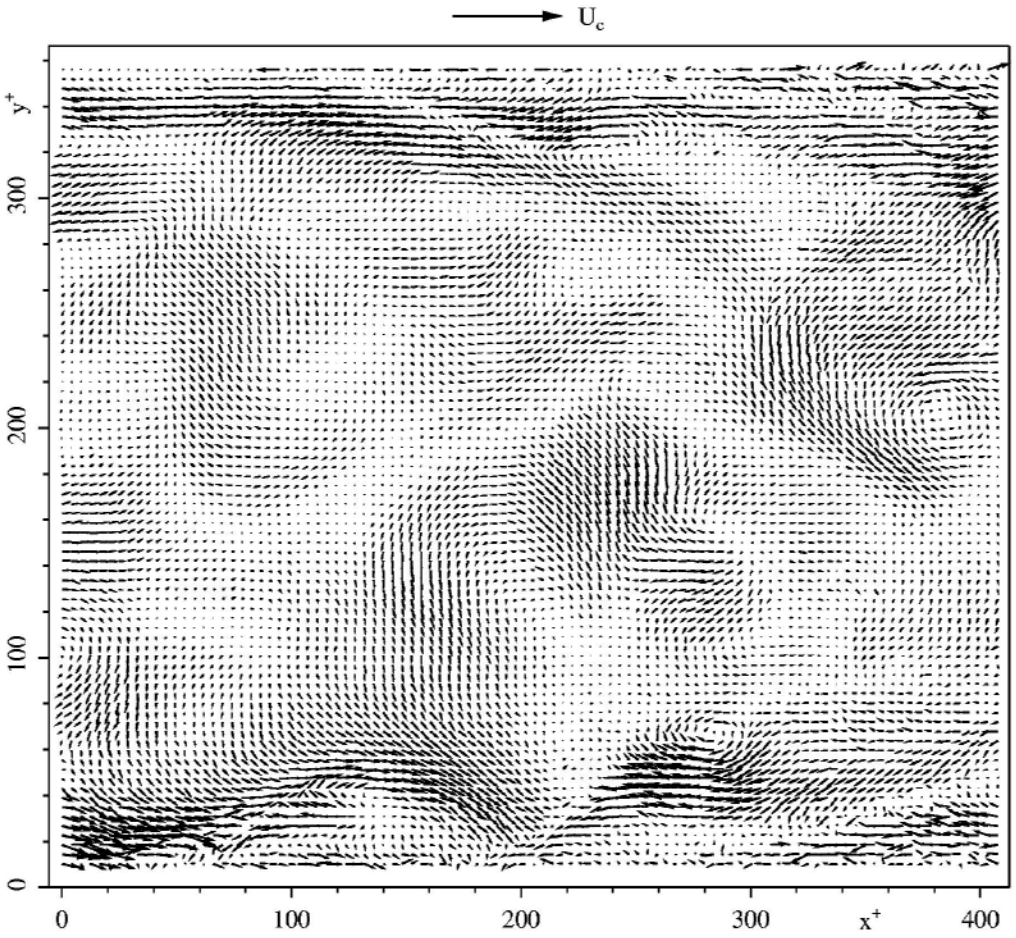




PIV analiza

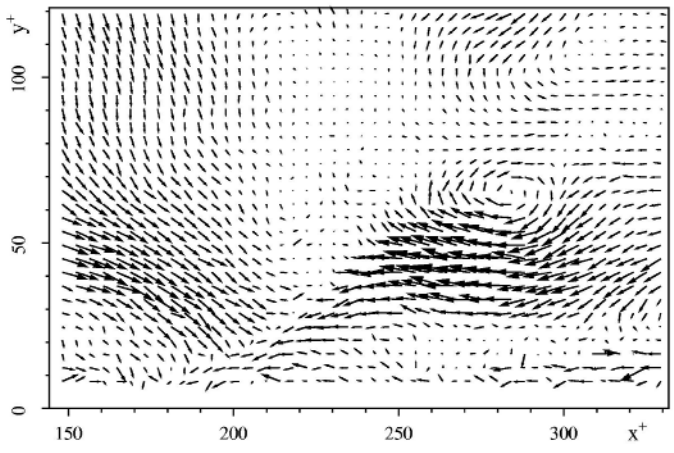


PIV rezultat



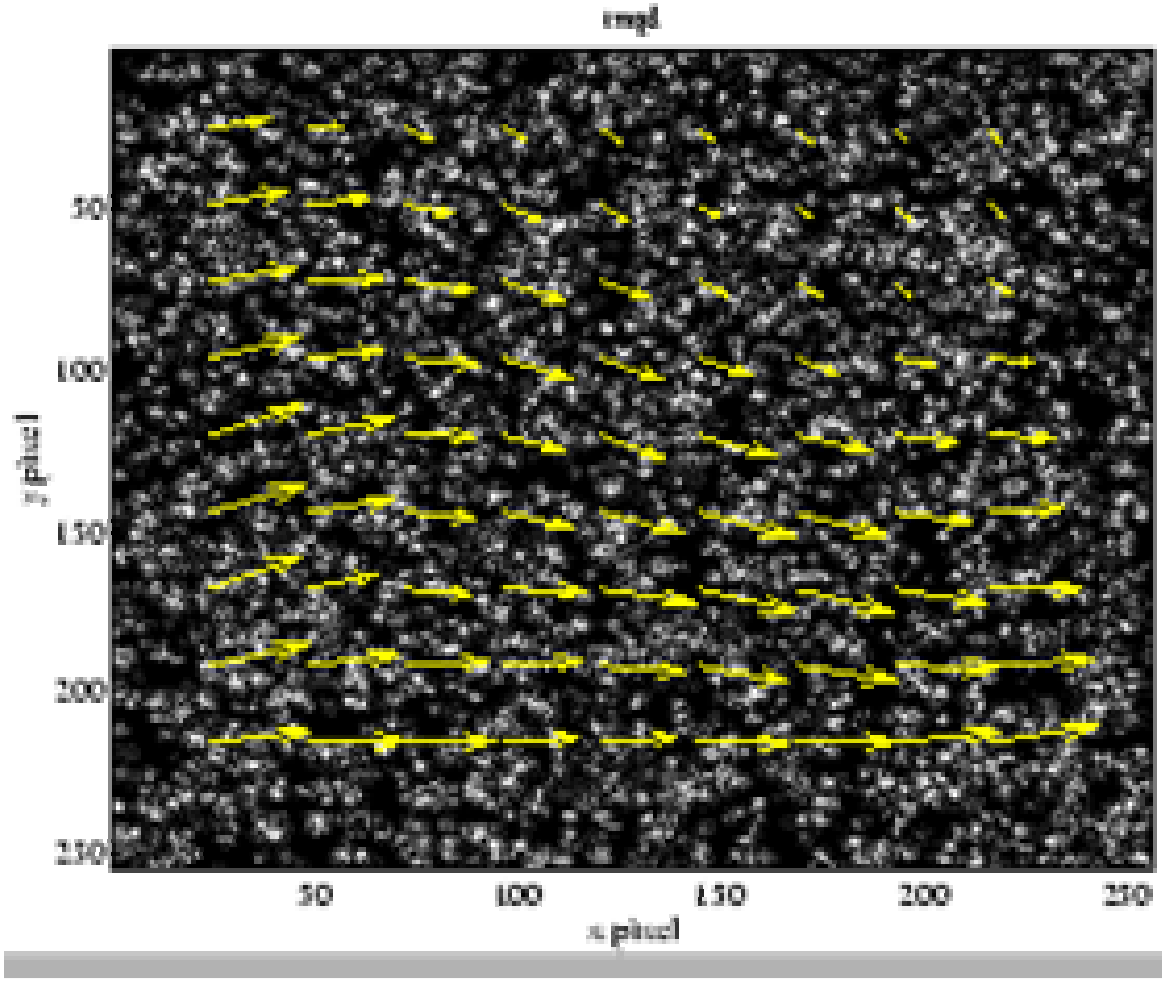
Turbulentni tok
***Re* = 5300**

“Hairpin” vrtlozi



Rezultat PIV

Opstrujavanje
***Re* = 4200**



Parametri PIV

- **Gustina izvora:**

$$N_S = \frac{C\Delta z_0}{M_0^2} \cdot \frac{\pi}{4} d_\tau^2$$

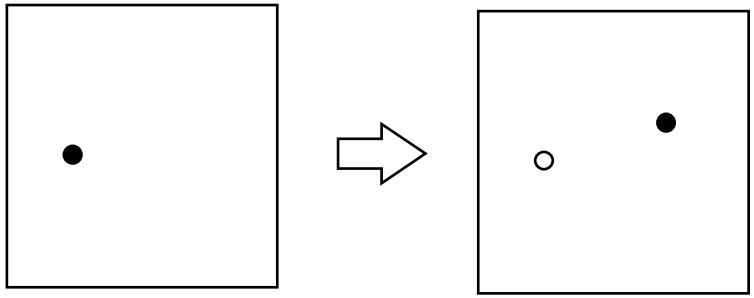
- **Gustina trasera:**

$$N_I = \frac{C\Delta z_0}{M_0^2} \cdot D_I^2$$

C	koncentracija trasera [m^{-3}]
Dz_0	debljina laserskog lista [m]
M_0	Uvećanje slike [-]
d_t	prečnik zrna trasera [m]
D_I	ispitivani prečnik [m]

Vrsta merenja u zavisnosti od gustine trasera

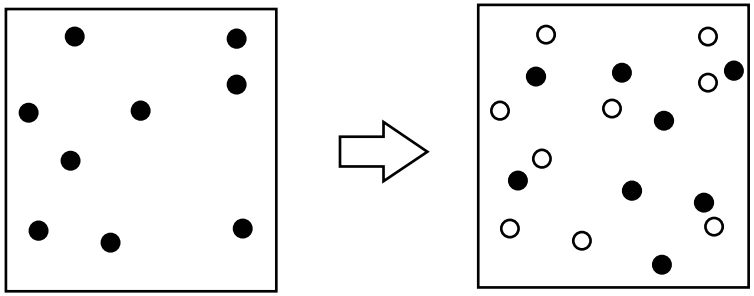
Gustina trasera (N_I)



Niska gustina trasera

$N_I << 1$

Particle Tracking Velocimetry (PTV)

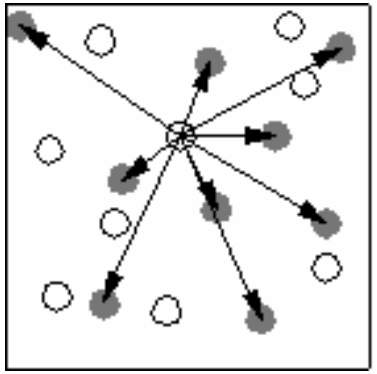


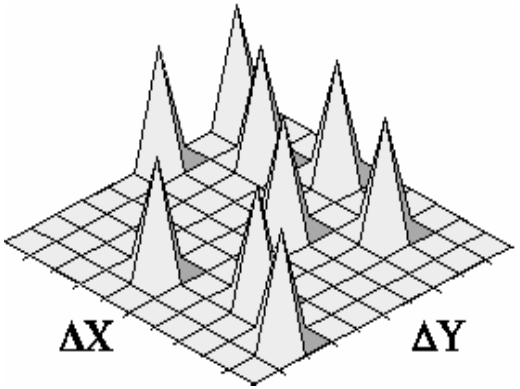
Visoka gustina trasera

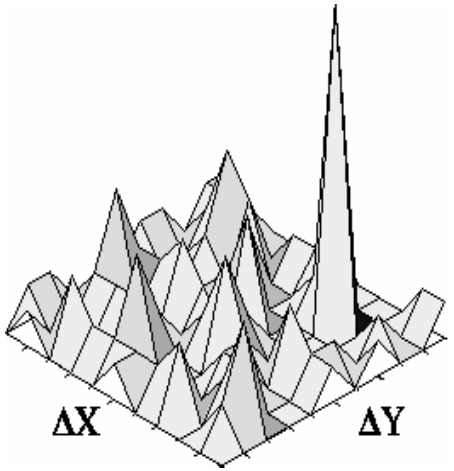
$N_I >> 1$

Particle image velocimetry (PIV)

Računanje kod visoke gustine trasera



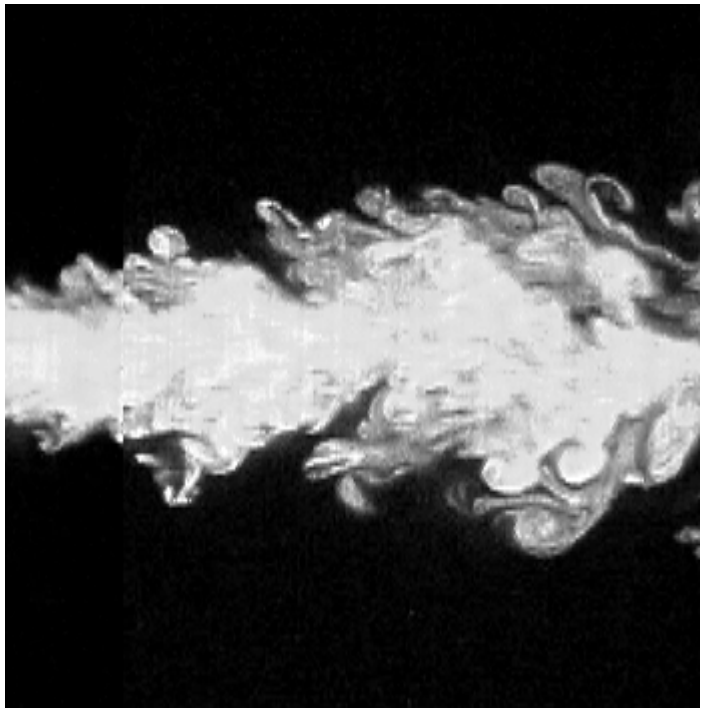


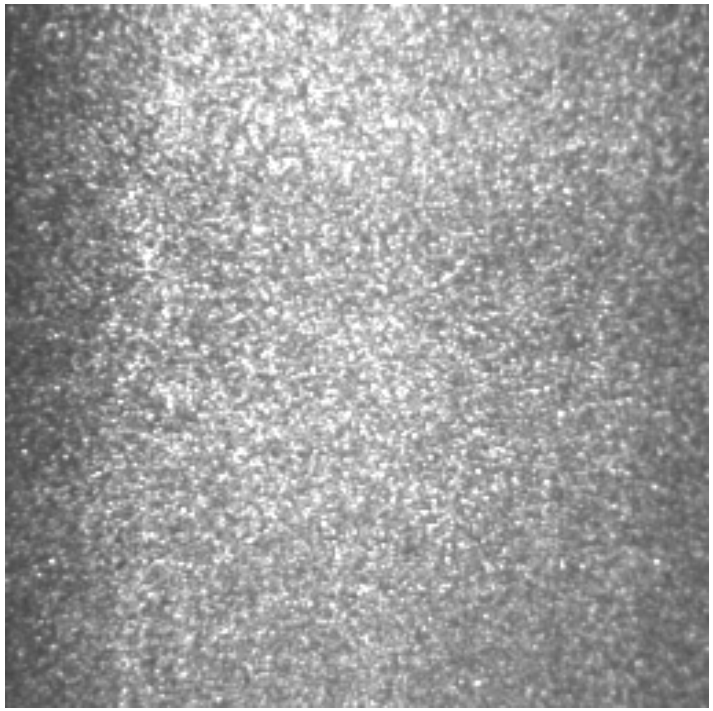


Prostorna korelacija:

$$C(\Delta X,\Delta Y)=\frac{\sum_{i=1}^{N}\sum_{j=1}^{N}\left[f_1(X_i,Y_j)-\overline{f_1}\right]\left[f_2(X_i+\Delta X,Y_j+\Delta Y)-\overline{f_2}\right]}{\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{N}\left[f_1(X_i,Y_j)-\overline{f_1}\right]^2}\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{N}\left[f_2(X_i+\Delta X,Y_j+\Delta Y)-\overline{f_2}\right]^2}}$$

Vizuelizacija & Merenja

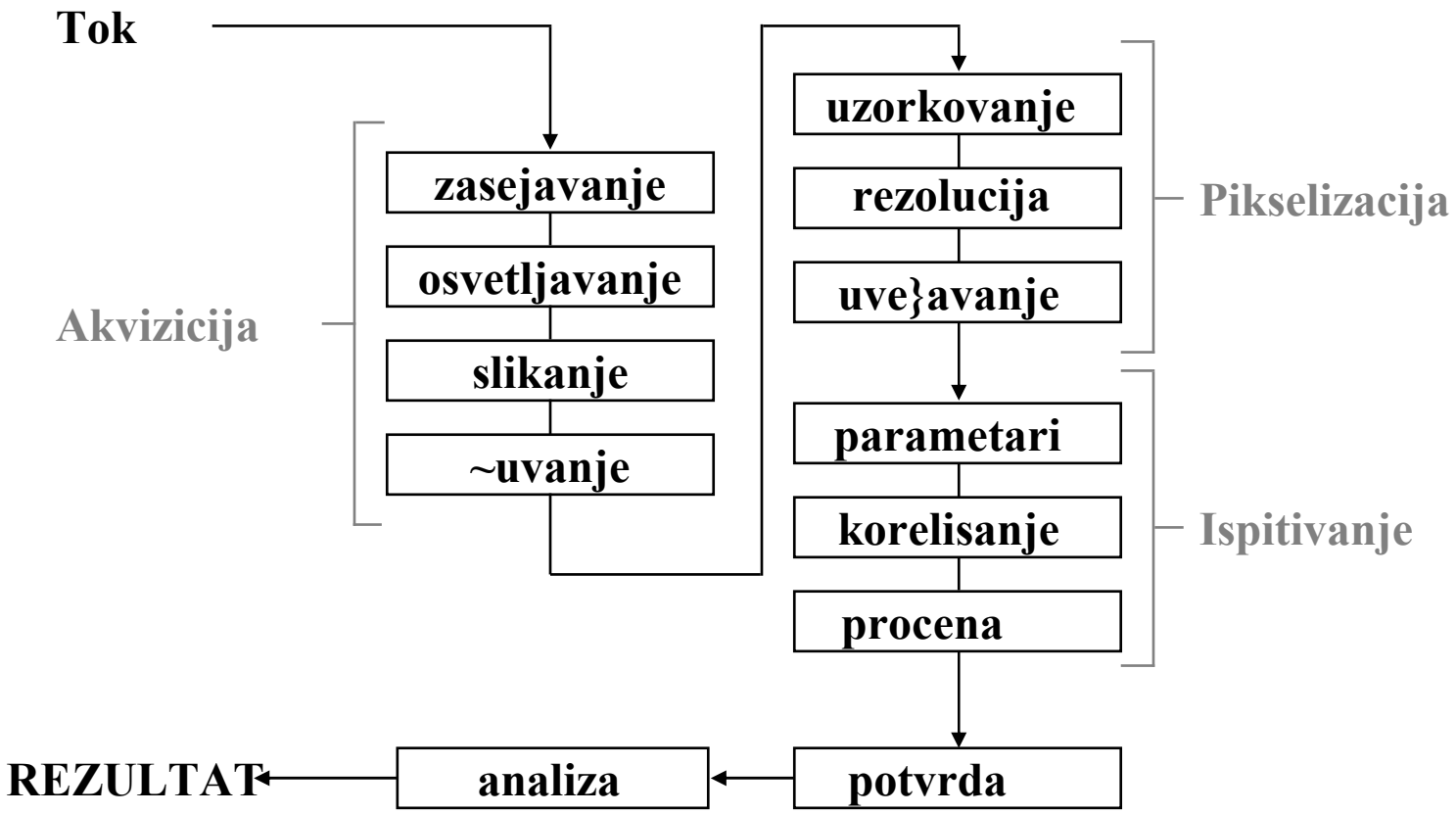




Potrebno je da

- **Traseri prate struju fluida**
- **su traseri raspoređeni homogeno po preseku**
- **su traseri ravnomerno raspore|eni u ispitivanom regionu**

Postupak

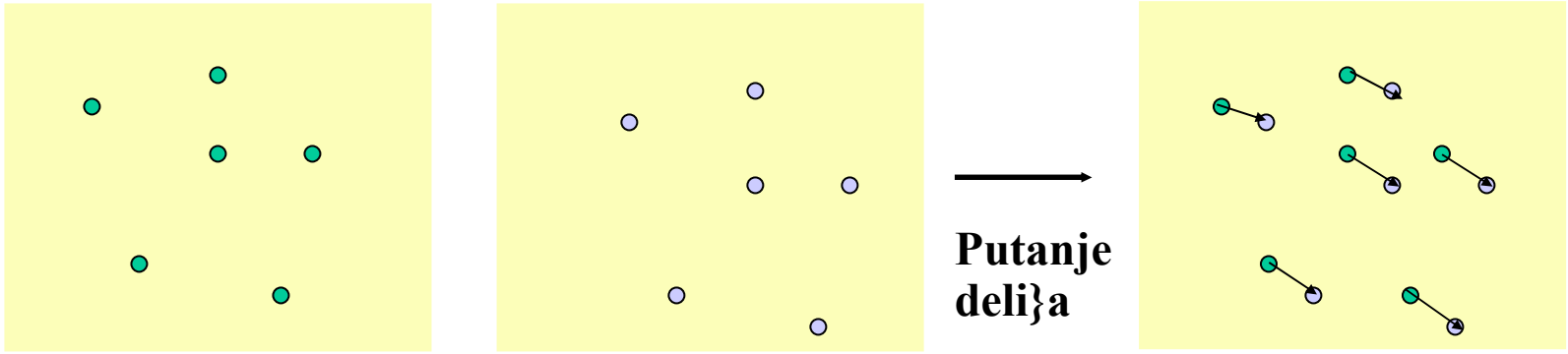

Tok
zasejavanje
osvetljavanje
slikanje
~uvanje
Akvizicija
uzorkovanje
rezolucija
uve}avanje
Pikselizacija
parametari
korelisanje
procena
Ispitivanje
potvrda
analiza
REZULTAT

Mane

- **Skupa**
- **Ne može se odrediti treća komponenta brzine**
- **Ograničena upotreba na terenu**
- **Ipak potrebna kalibracija**

Particle Tracking Velocimetry (PTV)

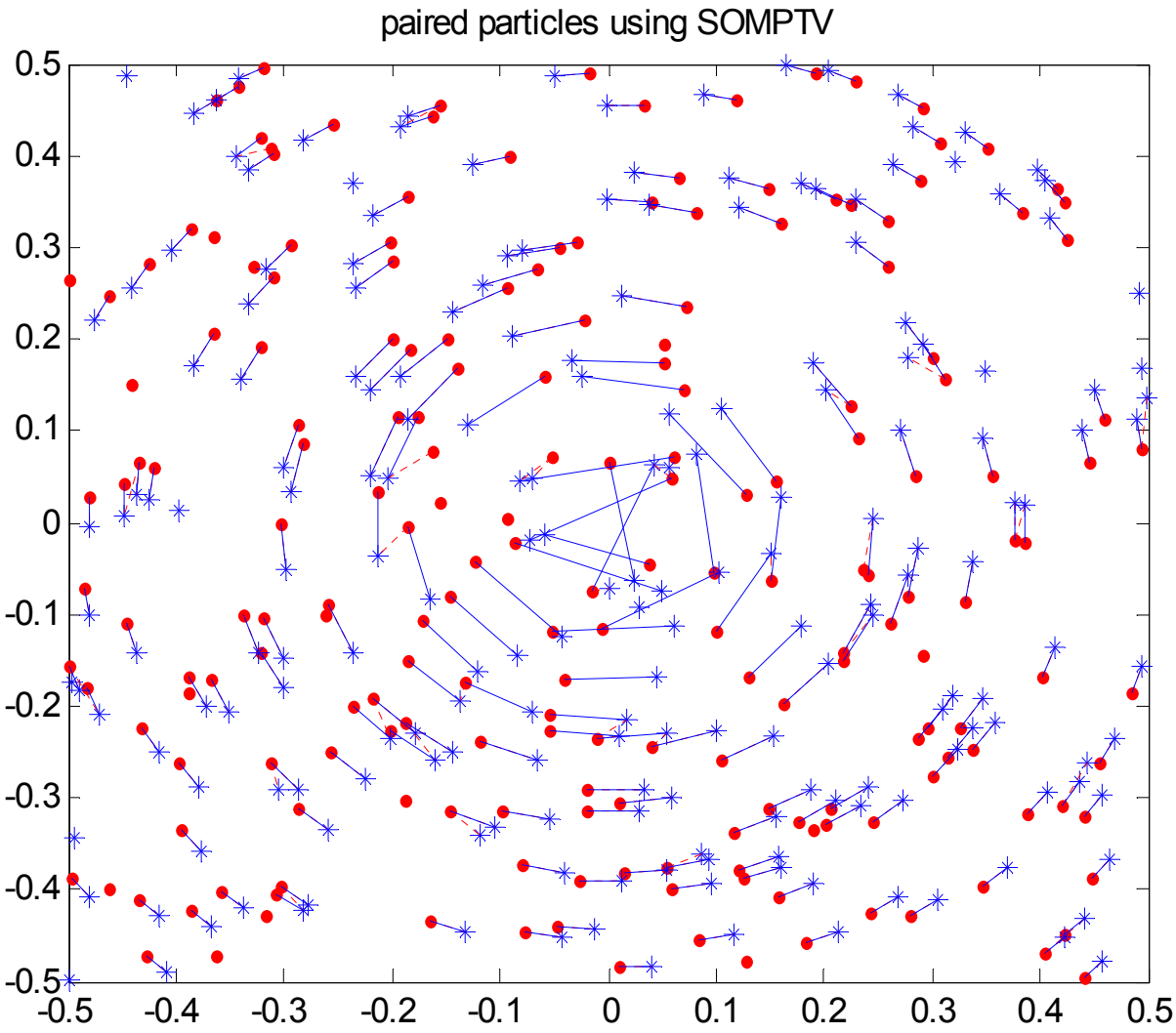
- **PTV je metoda za određivanje 2D polja brzina u poprečnom preseku u trenutku vremena poređenjem slika slabo zasejanog toka, snimljenih u malom vremenskom intervalu**



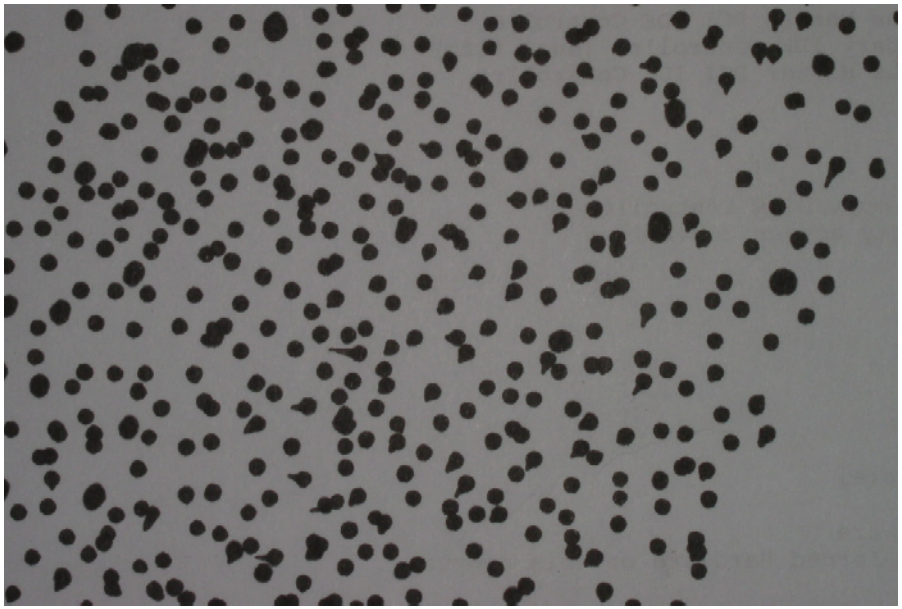
Slika 1 **Slika 2**

$$\text{Brzina} = \frac{\text{pomeraj}}{\text{vremenski interval}}$$

Rezultat

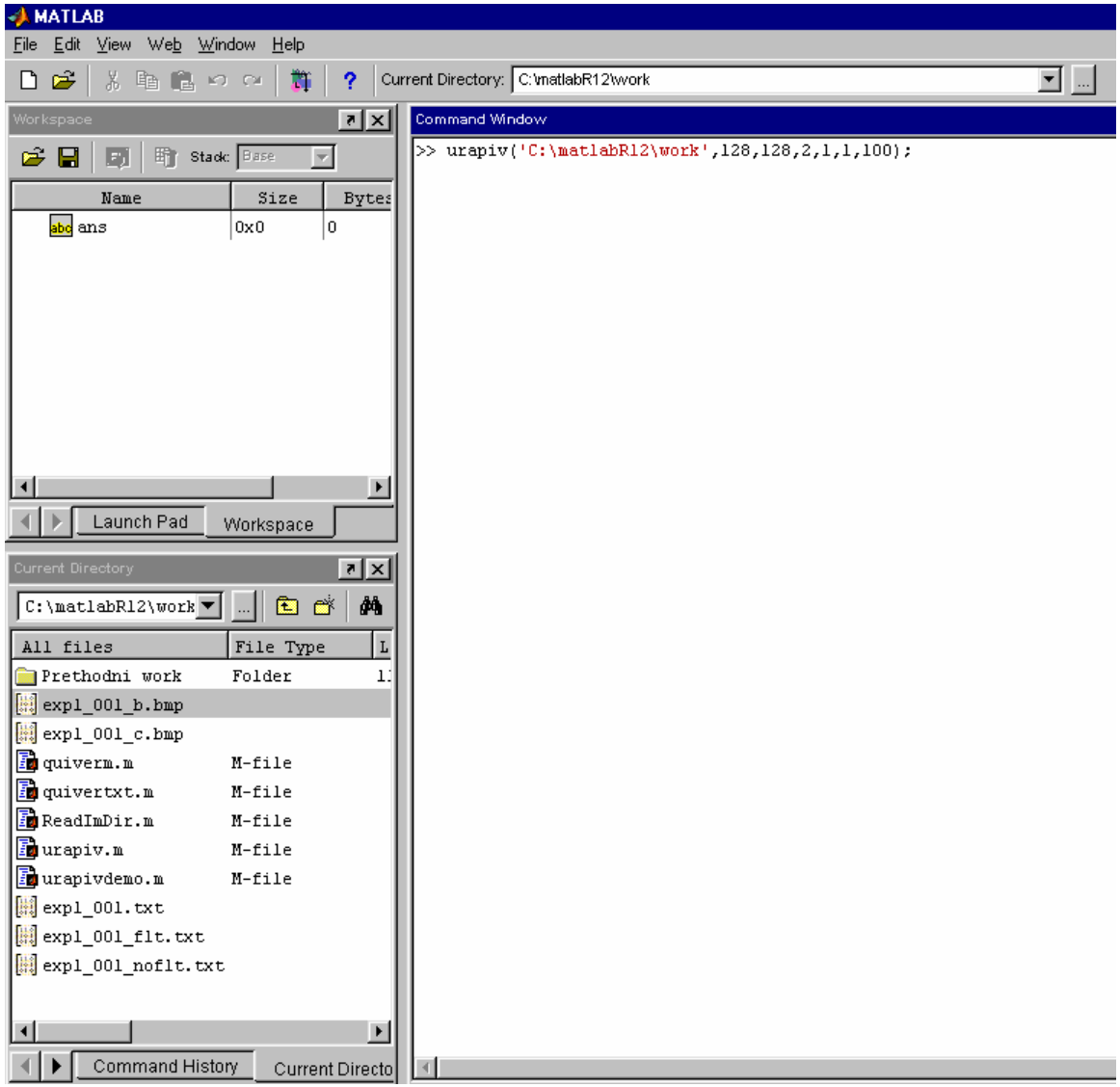

paired particles using SOMPTV
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5

Verifikacija metode

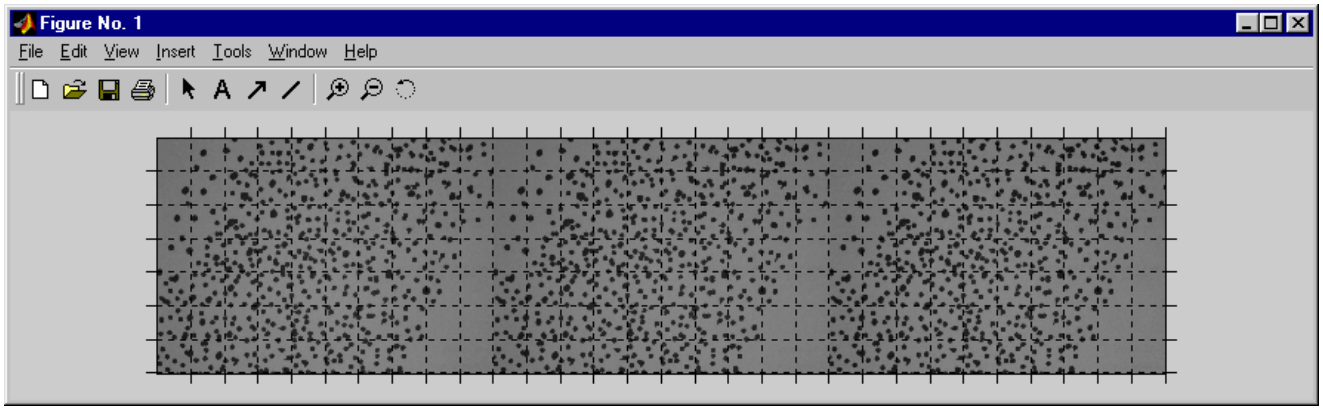


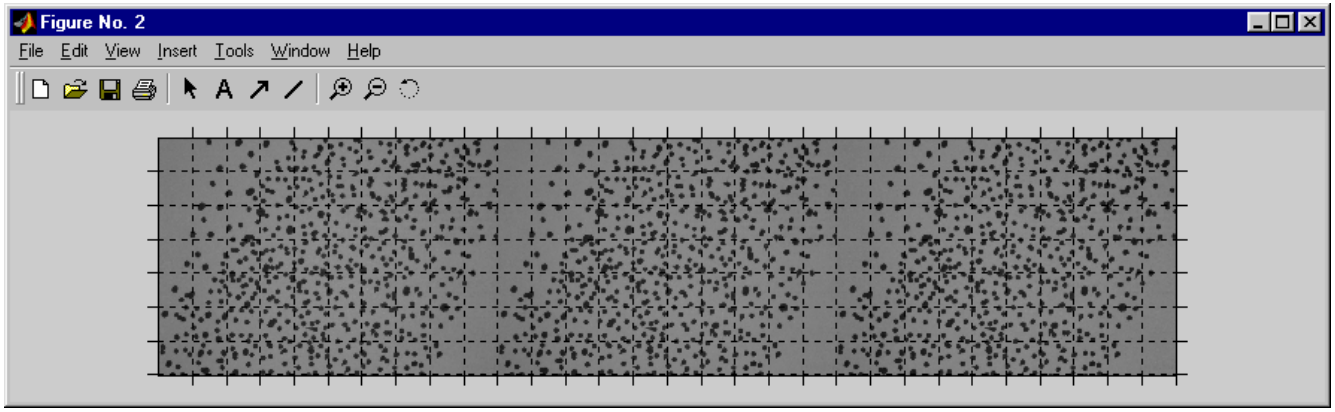
- Slikati papir za verifikaciju
- Prebaciti sa fotoaparata na računar
- Prebaciti iz formata .jpg u format .bmp
- Ponovo imenovati fotografije
- Pokrenuti program URAPIV

URAPIV - korak 1

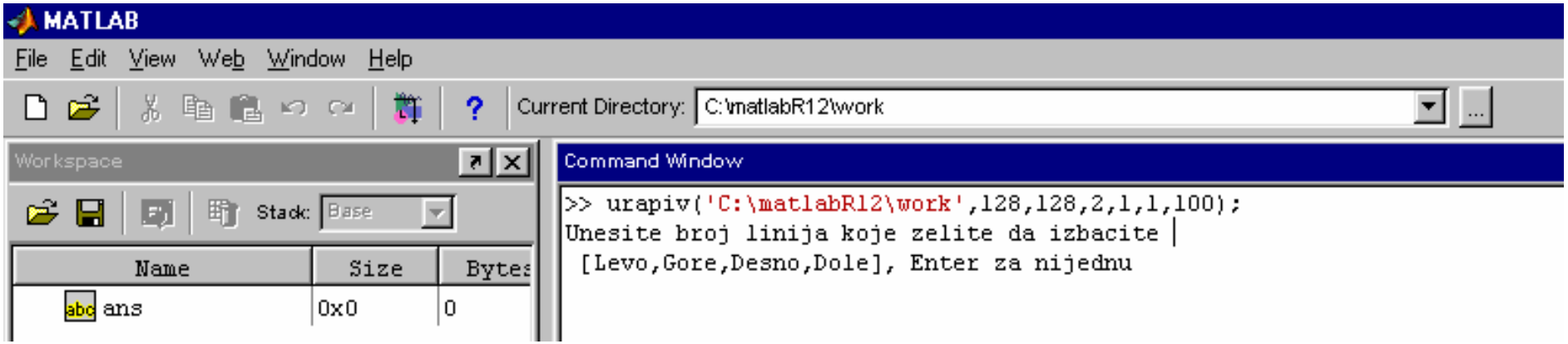


URAPIV - korak 2

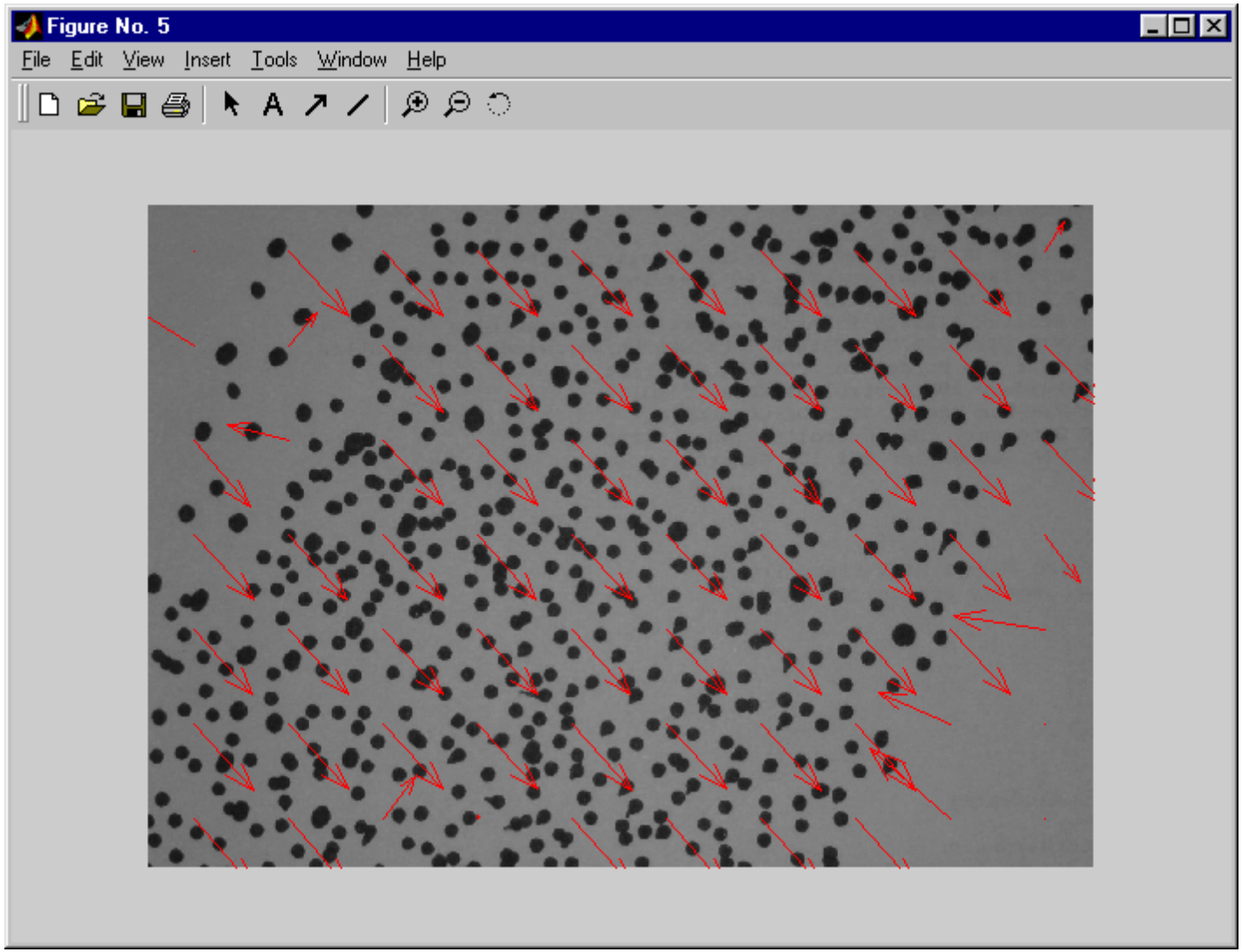




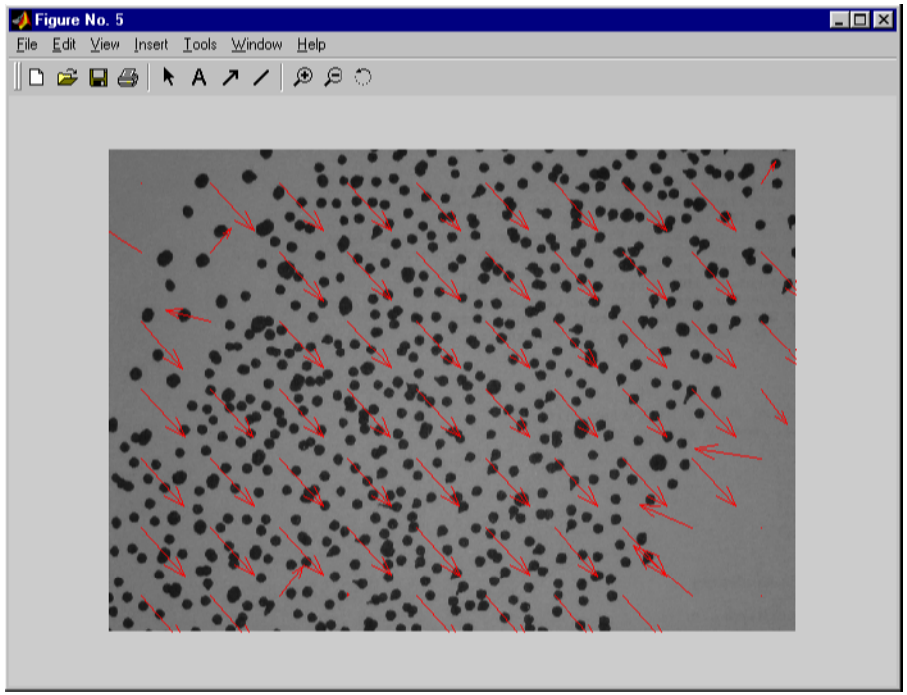
URAPIV - korak 3



URAPIV - korak 4

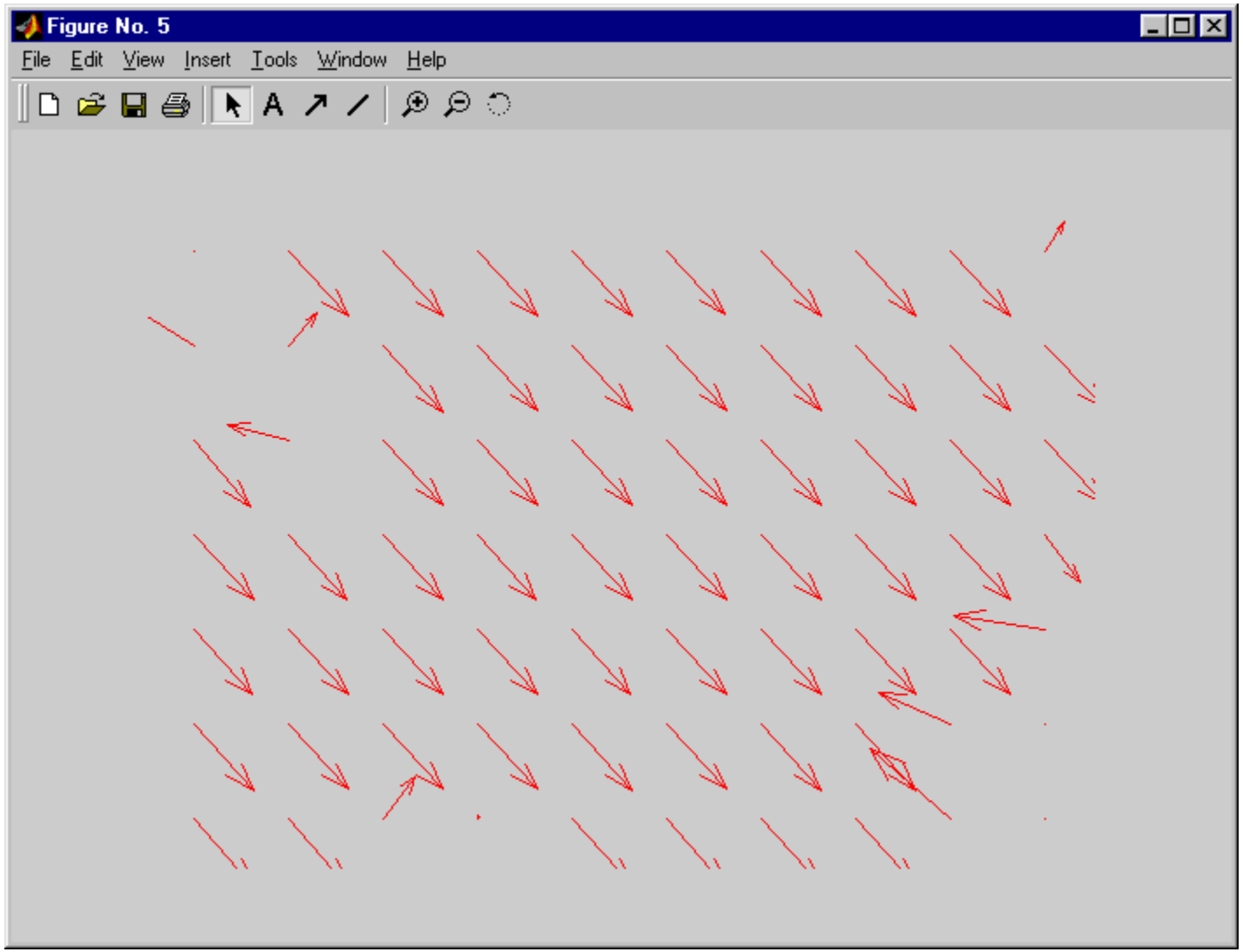


Kalibracija metode

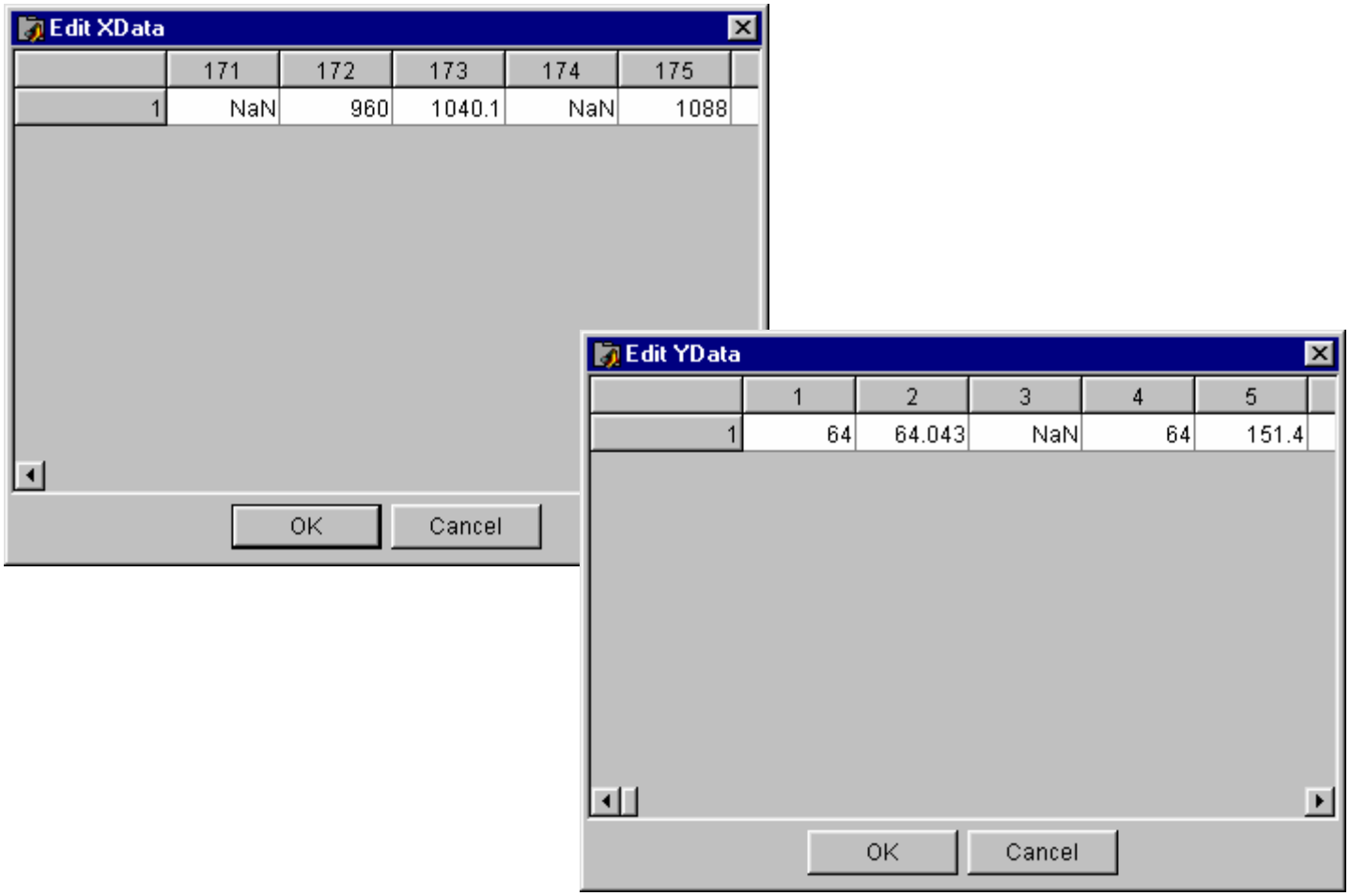


- Sve isto kao i za verifikaciju
- Potrebno je papir pomeriti za određenu dužinu
- Pronađi koordinate vektora
- Sračunati dužinu vektora
- Uporediti sa veličinom pomeranja papira

Kalibracija metode – korak 1



Kalibracija metode – korak 2



Kalibracija metode – korak 3

Dužina za koju je pomeren papir D

Dužina dobijenog vektora $L = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$

Koeficijent kalibracije $M = \frac{L}{D}$