Video Style Transfer

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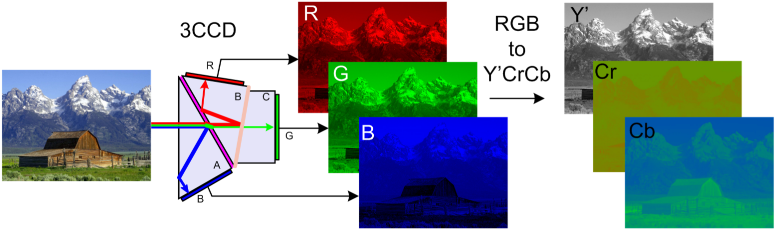
January 9, 2018

Outline

- Video
  60 frame per second

- Style Transfer

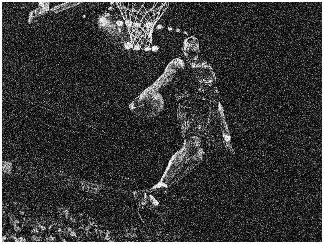
- Color Space Transfer



- L.I.Rudin, S.Osher and E.Fatemi, Nonlinear total variation based noise removal algorithms. 1992.

R.O.F Total Variation

(a) Original



(b) Noise

(c) Denoise 500 steps

(d) Denoise 1000 steps

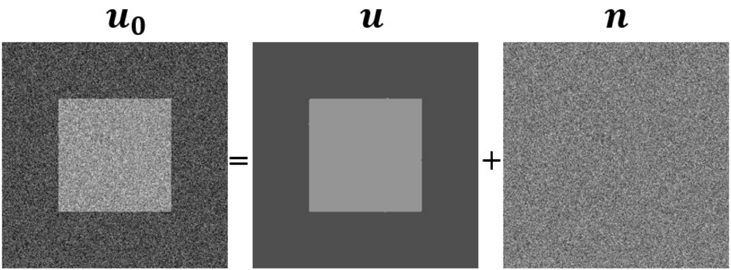
R.O.F Total Variation

- Ω image domain (Height, Width)
- Noisy image $u_0(x, y)$ where $x, y \in \Omega$
- Desired clean image $u(x, y)$

Then we have

$$u_0(x, y) = u(x, y) + n(x, y) \tag{1}$$

where $n(x, y)$ is the additive noise.



We have a minimization problem:

$$\min \int\int_{\Omega} \sqrt{u_x^2 + u_y^2} dxdy \tag{2}$$

subject to

$$\int\int_{\Omega} udxdy = \int\int_{\Omega} u_0 dxdy \tag{3}$$

since the white noise $n(x, y)$ in (1) is zero mean and

$$\int\int_{\Omega} \frac{1}{2}(u - u_0)^2 dxdy = \sigma^2 \tag{4}$$

where $\sigma > 0$ is given.

Let $x_i = ih$, $y_j = jh$, $i, j = 0, 1, ..., N$, with $Nh = 1$.
The numerical method is as follows:

$$u_{ij}^{n+1} = u_{ij}^n + \frac{\Delta t}{h}[\nabla_-^x(\frac{\nabla_+^x u_{ij}^n}{((\nabla_+^x u_{ij}^n)^2 + (m(\nabla_+^y u_{ij}^n, \nabla_-^y u_{ij}^n))^2)^{1/2}})$$

$$+\nabla_-^y(\frac{\nabla_+^y u_{ij}^n}{((\nabla_+^y u_{ij}^n)^2 + (m(\nabla_+^x u_{ij}^n, \nabla_-^x u_{ij}^n))^2)^{1/2}})]$$

$$-\Delta t \lambda^n (u_{ij}^n - u_0(ih, jh)) \quad (5)$$

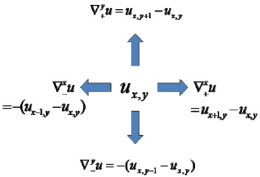
with boundary conditions

$$u_{0j}^n = u_{1j}^n, u_{Nj}^n = u_{N-1,j}^n, u_{i0}^n = u_{iN}^n = u_{i,N-1}^n \quad (6)$$

R.O.F Total Variation

Remark for (5),

$$\nabla^x_{\mp} u_{ij} = \mp(u_{i\mp 1,j} - u_{ij}), \quad \nabla^y_{\mp} u_{ij} = \mp(u_{i,j\mp 1} - u_{ij}) \tag{7}$$



$$m(a,b) = minmod(a,b) = (\frac{sgn\ a + sgn\ b}{2}) min(|a|,|b|) \tag{8}$$

$$\lambda^n = -\frac{h}{2\sigma^2}[\sum_{i,j}(\sqrt{(\nabla^x_+ u^n_{ij})^2 + (\nabla^y_+ u^n_{ij})^2} - \frac{(\nabla^x_+ u^0_{ij})(\nabla^x_+ u^n_{ij})}{\sqrt{(\nabla^x_+ u^n_{ij})^2 + (\nabla^y_+ u^n_{ij})^2}} - \frac{(\nabla^y_+ u^0_{ij})(\nabla^y_+ u^n_{ij})}{\sqrt{(\nabla^x_+ u^n_{ij})^2 + (\nabla^y_+ u^n_{ij})^2}}] \tag{9}$$

Parallel Program

Algorithm 1 R.O.F Total Variation Algorithm

Input: Noise Image u_0, *iter*, Δt, σ, ϵ

$u_t \leftarrow u_0$, $\lambda_t \leftarrow 1$
repeat
    Compute $\nabla^y_+ u_t$, $\nabla^y_- u_t$, $\nabla^x_+ u_t$, $\nabla^x_- u_t$
    Solve for u_t using Eq.(5)
    Solve for λ_t using Eq.(9)
until $I \geq iter$

Output: Denoise Image u_t

Comparison

figure

Reference

1. L.I.Rudin, S.Osher and E.Fatemi, Nonlinear total variation based noise removal algorithms. Physica D: Nonlinear Phnomena, 1992, 60(1): 259-268
2. T.F.Chen, G.H.Golub and P.Mulet, A nonlinear primal-dual method for total variation-based image restoration. SIAM Journal on Scientific Computing, 1996, 20(6): 1964-1997
3. D.P.Bertsekas, Nonlinear Programming. 2nd ed. Nashua: Athena Scientific, 1999: 9.
4. A.Chambolle, An Algorithm for Total Variation Minimization and Applications. Journal of Mathematical Imaging and Vision 20: 89-97, 2004

Assignment

- 許睿之: Serial R.O.F TV, PPT
- 湯沂達: CUDA R.O.F TV
- 彭詩峰: thread, OpenMP R.O.F TV

Q&A