Seminaria naukowe-doktoranckie - Seria terminów

PLIK | SERIA TERMINÓW | WSTAWIANIE | FORMATOWANIE TEKSTU | RECENZJA

Temat: Seminaria naukowe-doktoranckie

Lokalizacja: 208/C-3

Cykl: Występuje co piątek ważne 2013-10-04 do 2014-01-30 od 11:15 do 15:00

Otwarcie:

"Art. 11. 2. Warunkiem wszczęcia przewodu doktorskiego jest posiadanie wydanej lub przyjętej do druku publikacji naukowej w formie książki lub co najmniej jednej publikacji naukowej w recenzowanym czasopiśmie naukowym o zasięgu co najmniej krajowym, określonym przez ministra właściwego do spraw nauki na podstawie przepisów dotyczących finansowania nauki lub w recenzowanym sprawozdaniu z międzynarodowej konferencji naukowej [...]."

http://isap.sejm.gov.pl/DetailsServlet?id=WDU20110840455 (str. 72/98)

On application of stochastic counterpart approach to contrast-detection autofocusing

Ph.D. seminar

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October 4^{th}, 2013

Introduction

Presentation schedule

- **Introduction**
  - Autofocusing (AF)
  - Active vs. passive AF
  - Phase vs. contrast detection AF
- **Image variance in AF**
  - Assumptions
  - CD AF Circuit
  - Properties
- **Empirical CD AF**
  - Properties
- **Golden section search (GSS) algorithm**
  - Properties of GSS
  - Demonstration
- **Final remarks**

Introduction
Active AF

- Time of Flight (ToF)
  - Acoustic (echolocation)
  - Optical (short IR laser pulses)
- Structured light
  - Random or
  - Regular patterns
- **Properties**
  - Requires additional acoustic/optical signal generators.
  - Prone to some obstacles (*e.g.* glass).
  - Limited resolution (as of yet!).

Introduction

Passive AF - Phase detection (PD AF) approach

- Range finding (*e.g.* *Leica*'25, *Canon*, *Nikon*)
- SLR (*Honeywell*'78, *Minolta*, *Canon*, *Nikon*, ...) or SLT (*Canon*'65, *Sony*, ...)
- On-sensor (*Aptina*/*Nikon*'11, *Canon*, *Sony*, ...)
- **Properties**
  - **Dedicated hardware** required
    - Prisms,
    - Pellicle (*i.e.* semi-transparent) mirrors,
    - Half-masked pixels
  - Light lost (*e.g.* 1/3 EV)

Introduction

Passive AF - Contrast detection (CD AF) approach

- Contrast detection (CD AF) focus functions
  - Histogram-based
  - Gradient-based
  - Variance-based

A generic feature of CD AF algorithms

A distance information is restored from a sequence of images.

Introduction

Contrast detection AF

- The "sharpest image" is obtained when (intuitively!):
  - its **histogram** is the widest and the highest
  - its **gradient** (or **variance**) is the largest

Unimodality of a focus function

If a focus function is unimodal, the global search is an option.
Otherwise – it is a must!

Image variance in AF
CD AF circuit

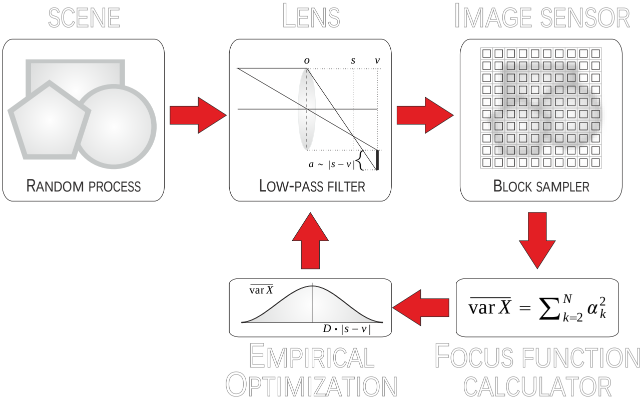


Figure: The block diagram of a contrast detection autofocus (CD AF) circuit

Image variance in AF

Assumptions

- The input (scene) process $U(x)$ is a white noise process or a continuous and wide-sense second order stationary one.
- $U(x)$ has a unimodal continuous non-negative correlation function

$$R_U(\tau) = E\{U(x)\, U(x+\tau)\}$$

  and a mean m_U.
- Both AA and lens filters have the respective box impulse responses

$$h(x) = (2A)^{-1}\, I_{[-A,A]}(x) \text{ and } k(x) = (2r)^{-1}\, I_{[-r,r]}(x).$$

Image variance in AF

Properties

Lemma

Denote by $Y(x) = (U \star h \star k)(x)$ *the image (output) process with a covariance function* $R_Y(\tau)$ *and a mean* m_Y*. The focus function (FF), defined as the variance of the image process,*

$$\mathrm{var}\{Y\} = R_Y(0) - m_Y^2,$$

is a unimodal function with a maximum at $r = 0$.

Corollary

Let the impulse response of the lens filter have the appropriate nth order (cardinal) B-splines impulse responses. Then, the lemma above holds since for any $n = 1, 2, \ldots$

$$B_n(x) = I_{[-1/2,1/2]}(x) \star B_{n-1}(x).$$

Empirical CD AF

Properties

- In practice the variance of the image is not available.
- The image captured by a sensor is corrupted by
  - additive **Gaussian** thermal and **Poissonian** shot noises

Empirical focus function (EFF) – a variance estimate

We estimate the EFF from single image realizations – under assumption that the scene is an *ergodic process*.

Lemma

Let $Y(x) = W(x) + Z(x)$, where $W(x)$ and $Z(x)$ are wide-sense fourth-order stationary and mutually independent ergodic processes. The EFF of the following form

$$\bar{\sigma}_Y^2 = \frac{1}{2T}\int_{-T}^{T}\left\{Y^2(\xi) - \left[\frac{1}{2T}\int_{-T}^{T} Y(\xi)\, d\xi\right]^2\right\} d\xi$$

converges to the FF with the rate $\mathcal{O}\left(T^{-1}\right)$ in the MSE sense.

Golden section search
Properties

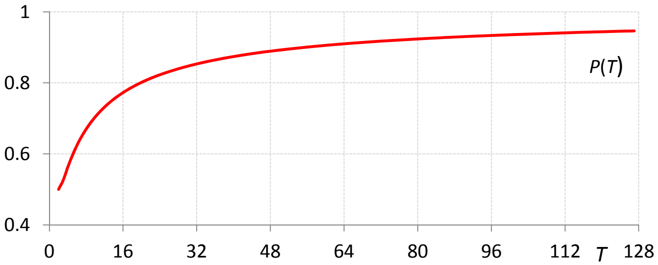
- The *golden-section search* procedure requires $M = c \log_2 T$ steps, small $c > 0$, where T is a number of row/column pixels

Theorem

Let $p = 1 - T$. The probability that in M steps we find a maximum equals to

$$P(T) = \left(1 - T^{-1}\right)^{\log_2 T}.$$

- The probability of success tends to 1 with growing T



Golden section search

Demonstration

GGS AF demonstration

GGS AF demonstration

Final remarks

Conclusions

Conclusion

A naive application of the **deterministic** GSS algorithm to the **stochastic** CD AF problem is shown to be reasonable.

- CD AF advantages
  - **Affordability** – any device equipped with a digital sensor
  - **Simplicity** – add-on implementation
  - **Video signal compatibility** – precision limited by the hardware
- CD AF disadvantages
  - **Slowness** – lack of distance information
  - **No direct tracking ability** – lack of direction information
  - **Energy consumption** – a penalty for a back-and-forth régime