CLAFITE: Classificazione della fibrillazione ventricolare a supporto della decisione terapeutica

Prof. Marco C. Campi (DII)

Prof. Frank A. Rasulo (DSMC)

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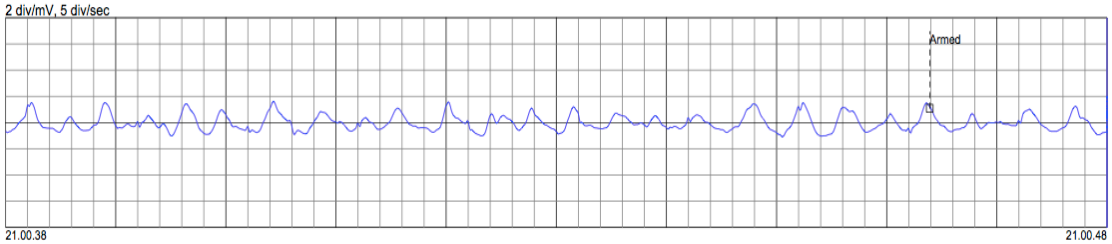
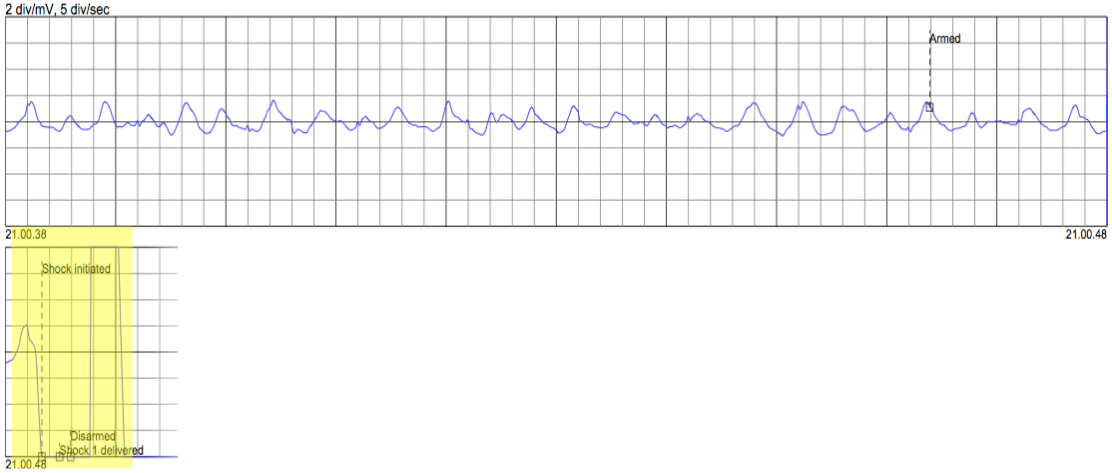
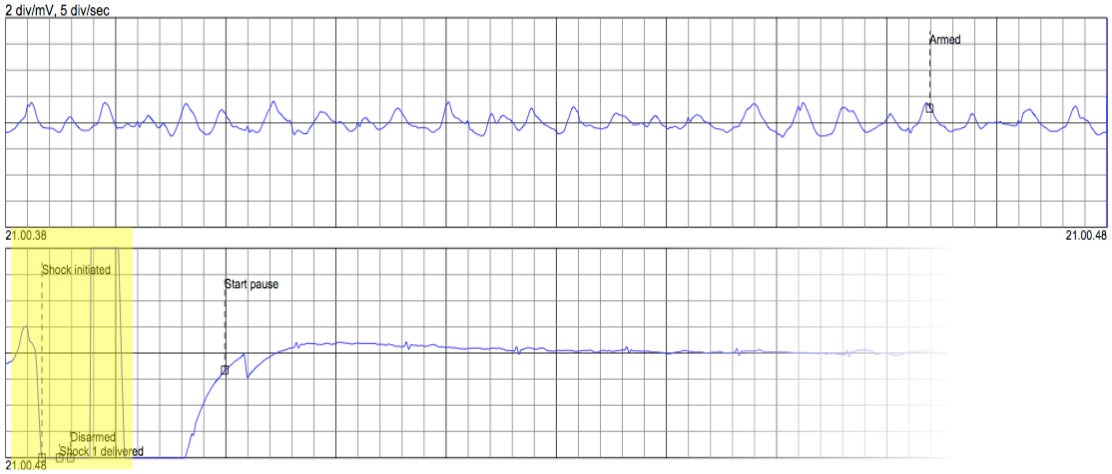
Presentazione di: Algo Carè (DII)


2 div/mV, 5 div/sec
Armed
21.00.38
21.00.48


2 div/mV, 5 div/sec
Armed
21.00.38
21.00.48
Shock initiated
Disarmed
Shock 1 delivered
21.00.48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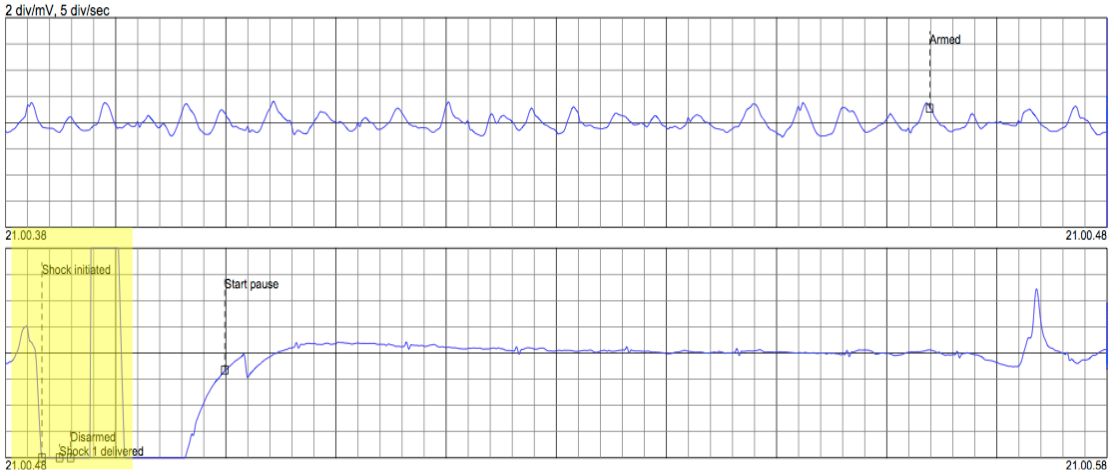
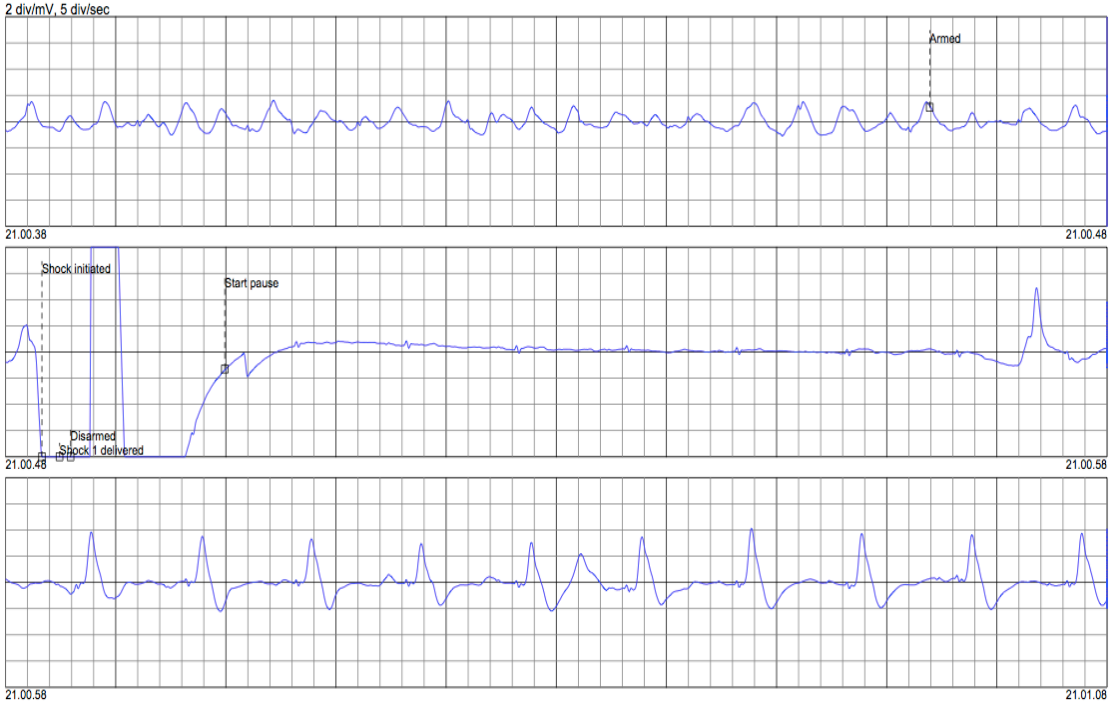
Armed
21.00.38
21.00.48
Shock initiated
Start pause
Disarmed
Shock 1 delivered
21.00.48


2 div/mV, 5 div/sec
Armed
21.00.38
21.00.48
Shock initiated
Start pause
Disarmed
Shock 1 delivered
21.00.48
21.00.58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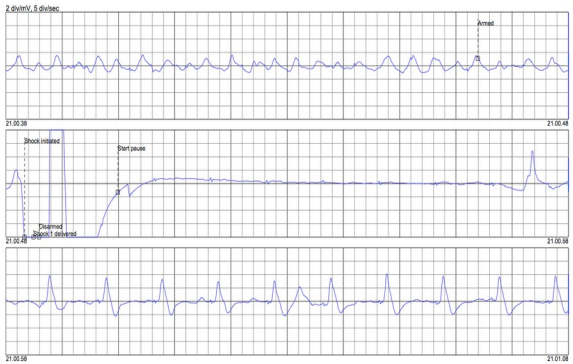
21.00.48
Shock initiated
Start pause
Disarmed
Shock 1 delivered
21.00.48
21.00.58
21.00.58
21.01.08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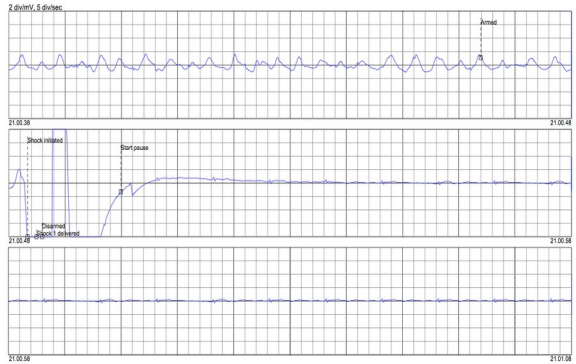
?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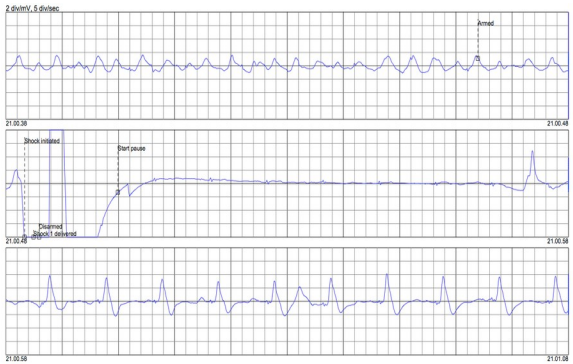
"each minute of delay before defibrillation reduces the probability of survival to discharge by 10-12%"

European resuscitation council guidelines for resuscitation 2015.



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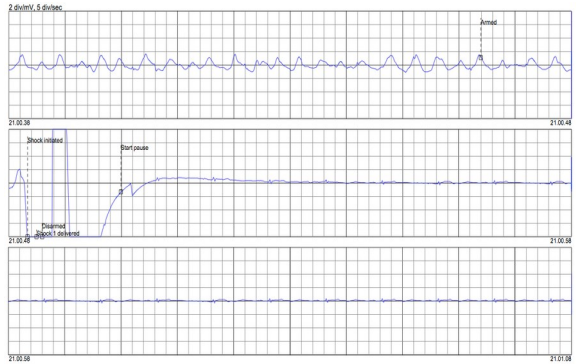

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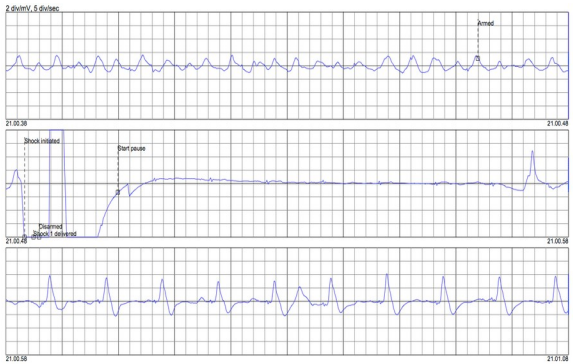

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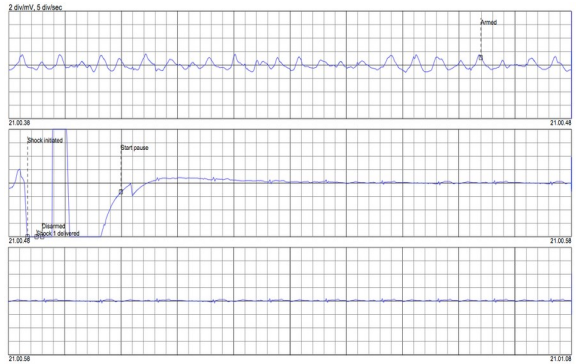
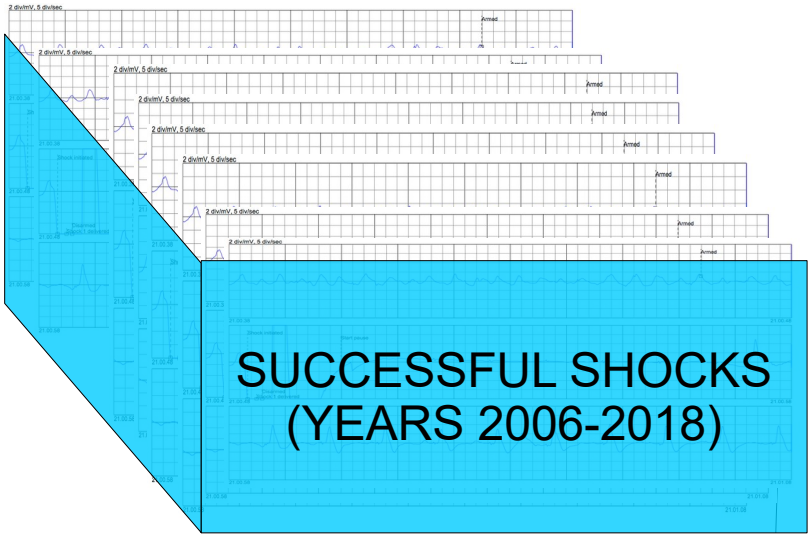
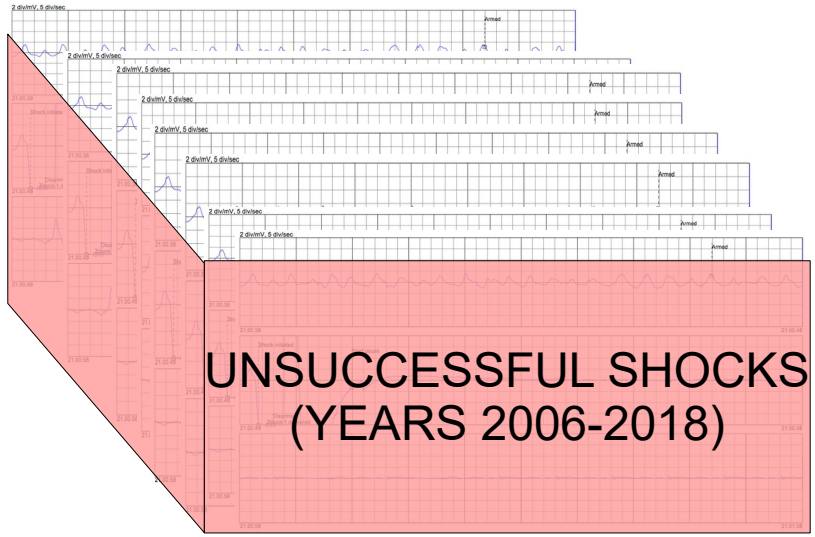


high energy shocks can cause damage (myocardial injury)

Learning from experience





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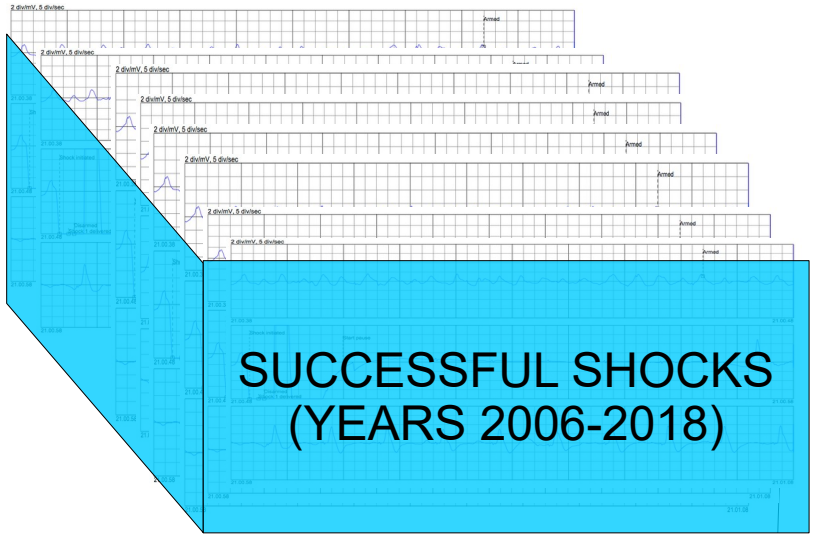
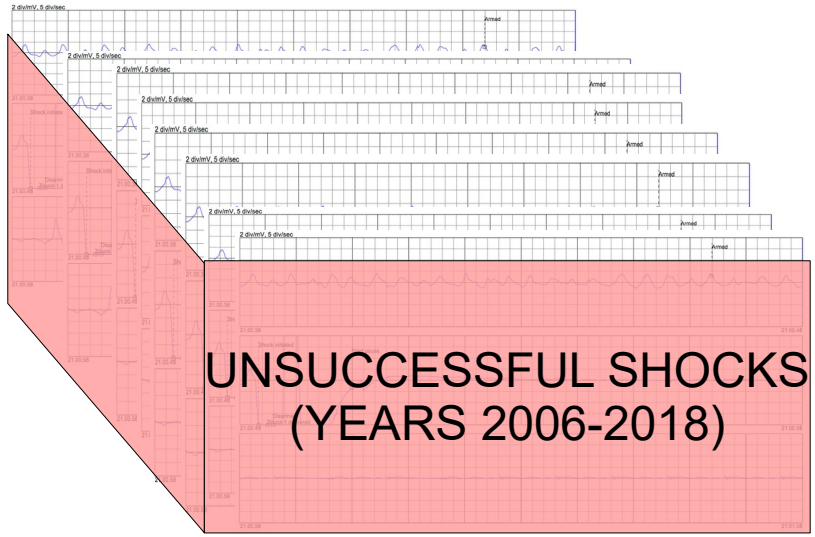
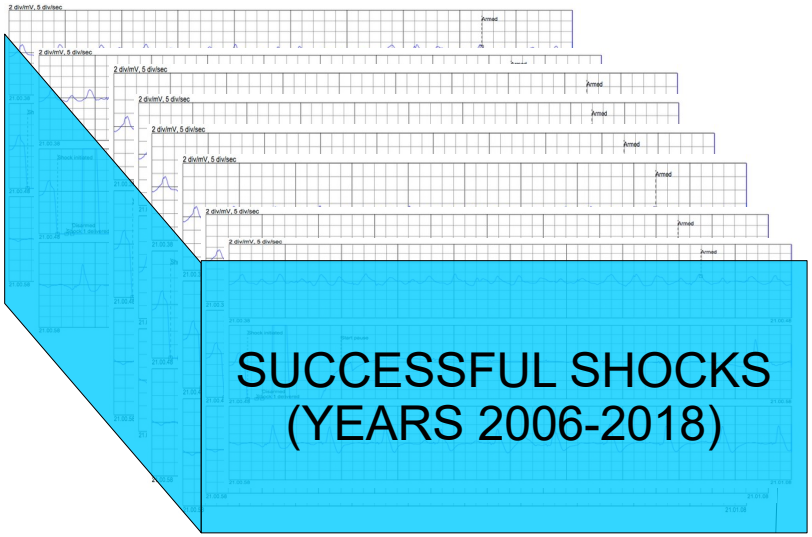
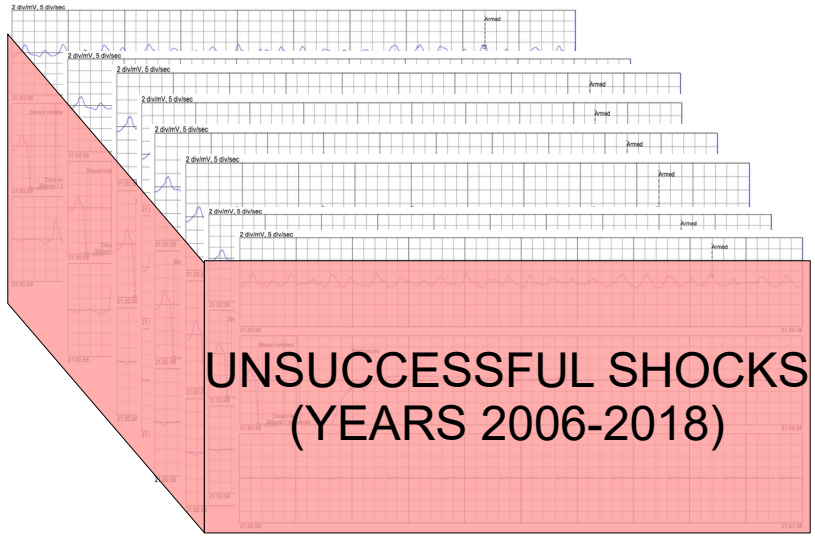




PAST

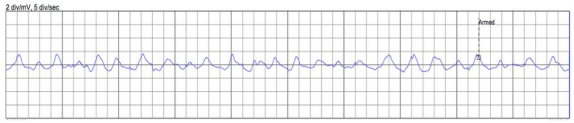
Learning from experience



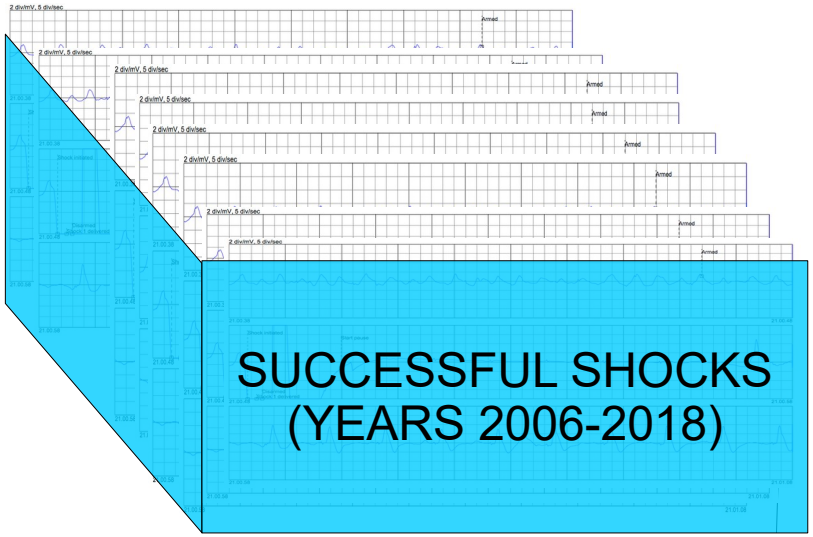


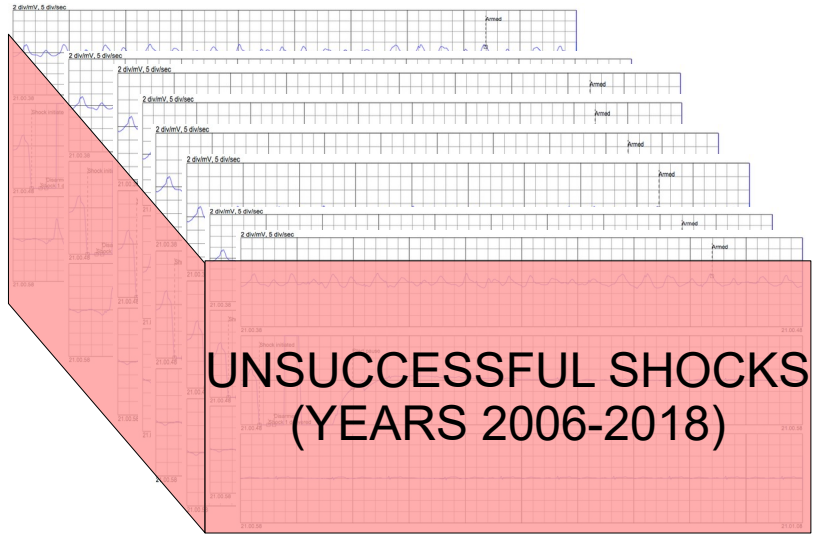
PAST

PRESENT



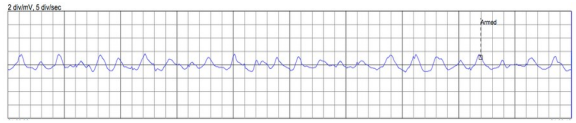
Learning from experience





PAST

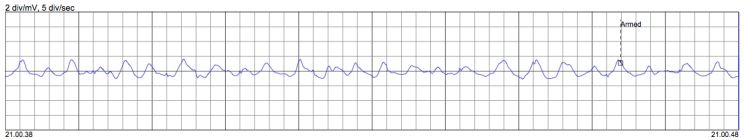
PRESENT



?

SUCCESS FAILURE

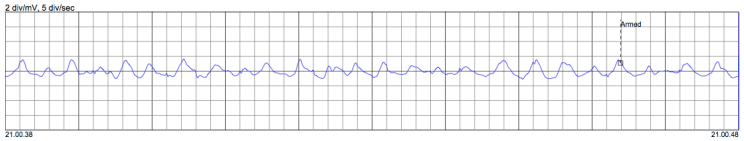
Automatic learning



- PTT (peak to peak amplitude)
- Amax (maximum amplitude)
- Amin (minimum amplitude)
- RMS (root mean square)

- DF (dominant frequency)
- CF (spectral centroid frequency)
- EF (edge frequency)
- AMSA (amplitude spectral area)

Automatic learning



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- EF (edge frequency)
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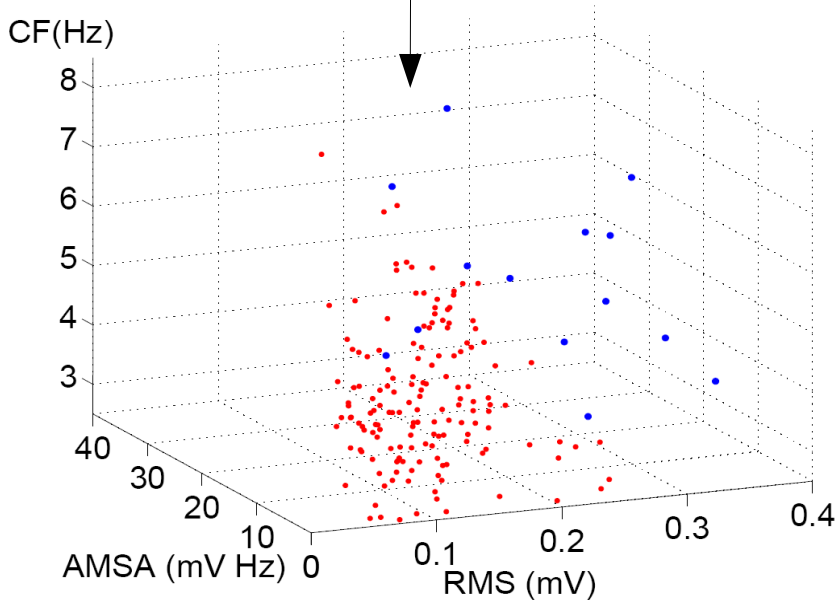
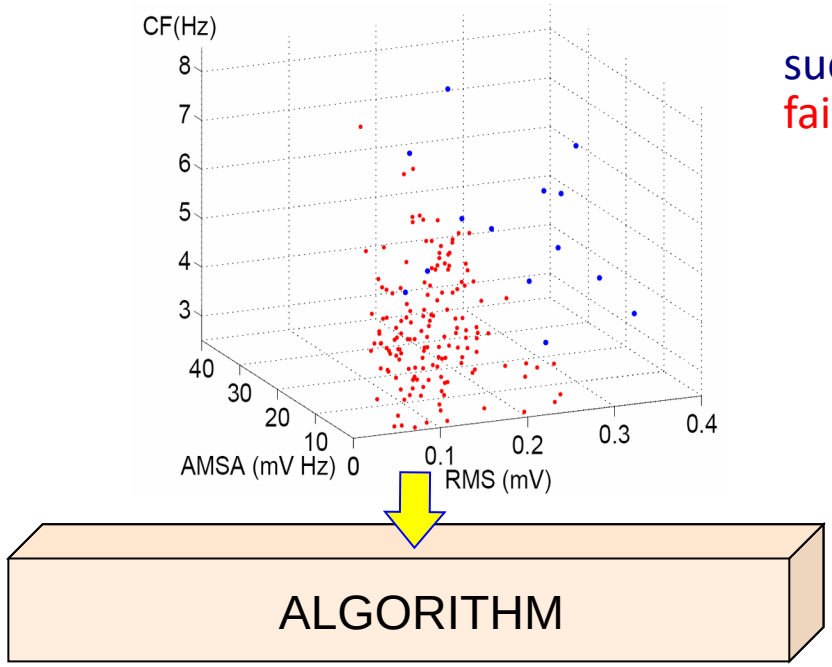
success (1)
failure (0)



Automatic learning



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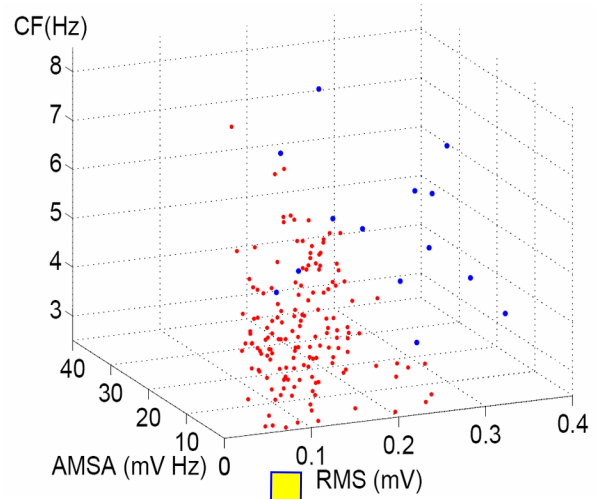

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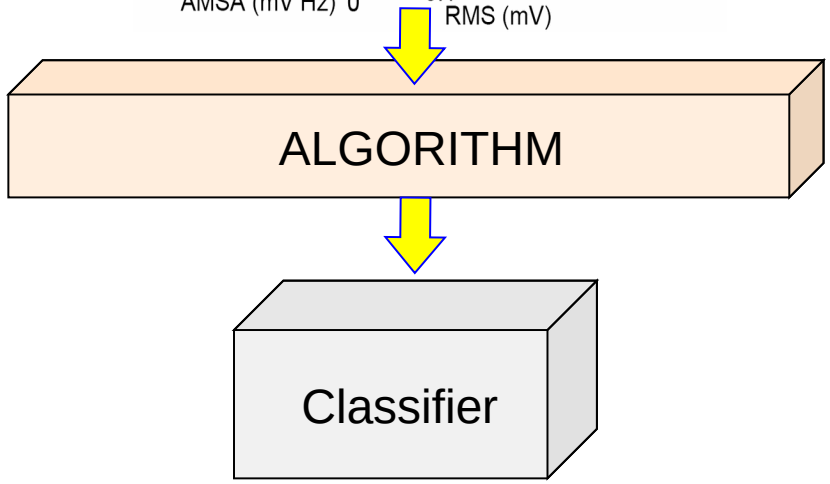
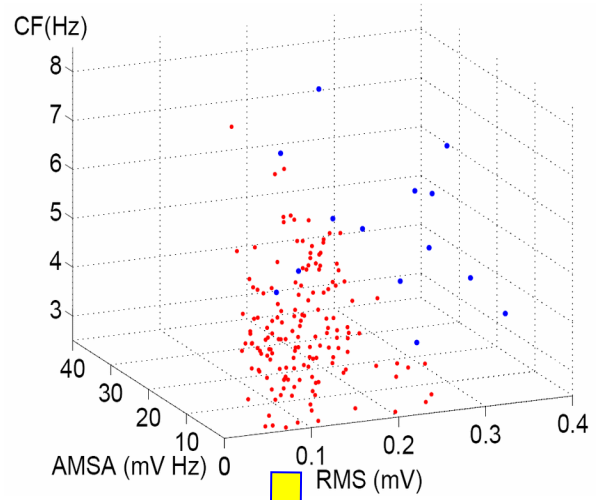
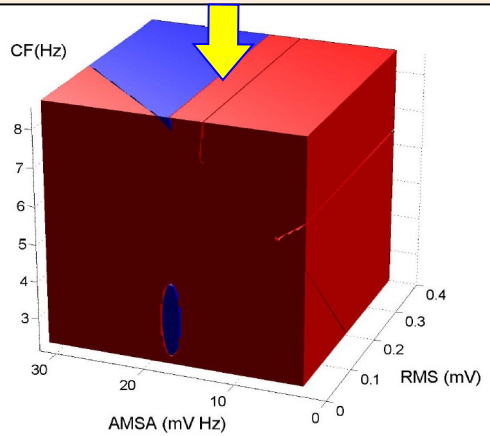


Automatic learning



success (1)
failure (0)

ALGORITHM



$$\hat{y}(\cdot) : \mathbb{R}^3 \rightarrow \{1, 0\}$$

Classification

$$\Pr\{\text{Error}\}$$

Classification

$$\Pr\{\text{Error}\}$$

INVISIBLE

Classification

$\Pr\{\text{Error}\}$

INVISIBLE

Complexity of the Classifier

Classification

$\Pr\{\text{Error}\}$

INVISIBLE

VISIBLE (and controllable)

Complexity of the Classifier

Classification

$$\Pr\{\text{Error}\}$$

INVISIBLE

VISIBLE (and controllable)

Complexity of the Classifier

A lot of informative features → low complexity → small error

Classification

$$\Pr\{\text{Error}\}$$

INVISIBLE

VISIBLE (and controllable)

Complexity of the Classifier

A lot of informative features → low complexity → small error

A few uninformative features → high complexity → large error

Classification

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Complexity of the Classifier

A lot of informative features → low complexity → small error

A few uninformative features → high complexity → large error

"Ventricular defibrillation: Classification with GEM and a roadmap for future investigations"
F. Baronio, M. Baronio, M.C. Campi, A. Carè, S. Garatti, G. Perone
2017 IEEE 56th Annual Conference on Decision and Control (CDC), 2718-2723

A fundamental distinction

Probability of **error**

A fundamental distinction

Probability of **error**

Pr(“success” | failure)

Pr(”failure” | success)

A fundamental distinction

Probability of **correct classification**

1 – Pr(”success” | failure)

1 – Pr(”failure” | success)

A fundamental distinction

Probability of **correct classification**

1 – Pr(”success” | failure)
=Pr(”failure” | failure)

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A fundamental distinction

Probability of **correct classification**

1 – Pr(”success” | failure)
=Pr(”failure” | failure)

specificity

1 – Pr(”failure” | success)
=Pr(”success” | success)

sensitivity

A fundamental distinction

Probability of **correct classification**

1 – Pr(”success” | failure)
=Pr(”failure” | failure)

specificity

Target

50%

1 – Pr(”failure” | success)
=Pr(”success” | success)

sensitivity

Target

95%

Classification

$$\Pr\{\text{Error}\}$$

INVISIBLE

VISIBLE (and controllable)

Complexity of the Classifier

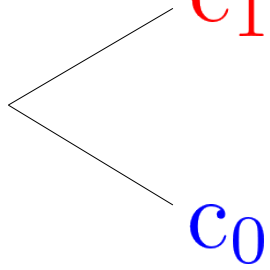
Classification

$\Pr\{\text{Error}\}$

INVISIBLE

VISIBLE (and controllable)

Complexity of the Classifier



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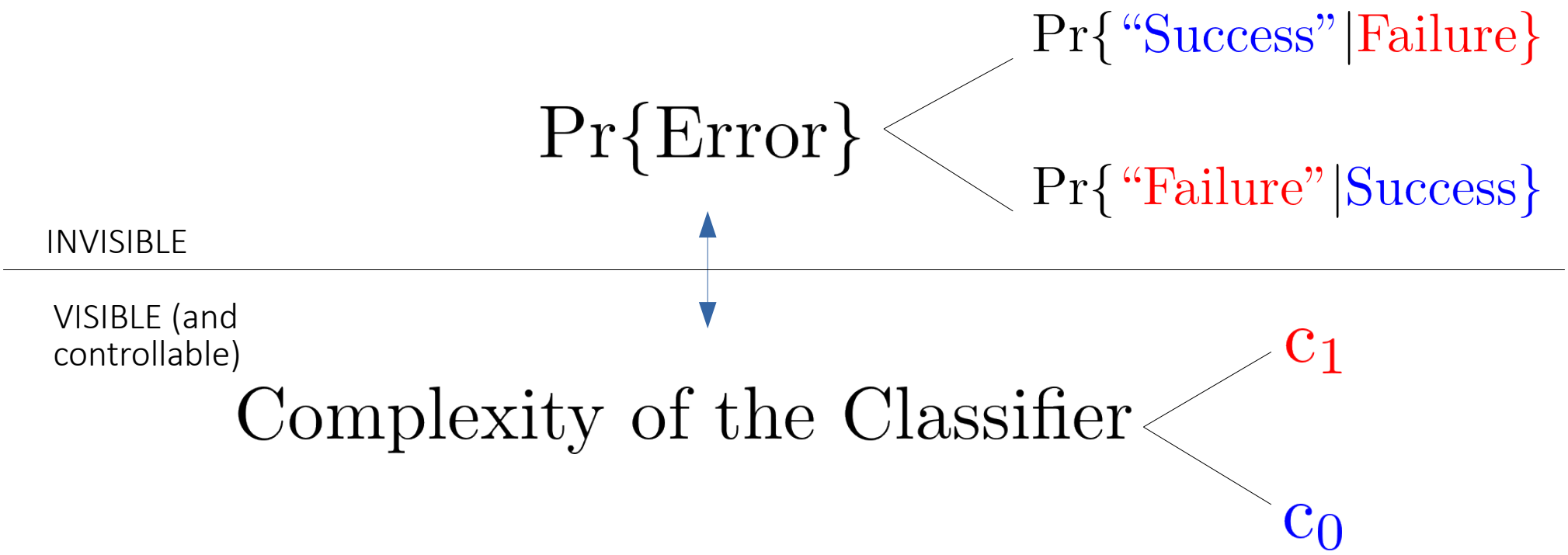
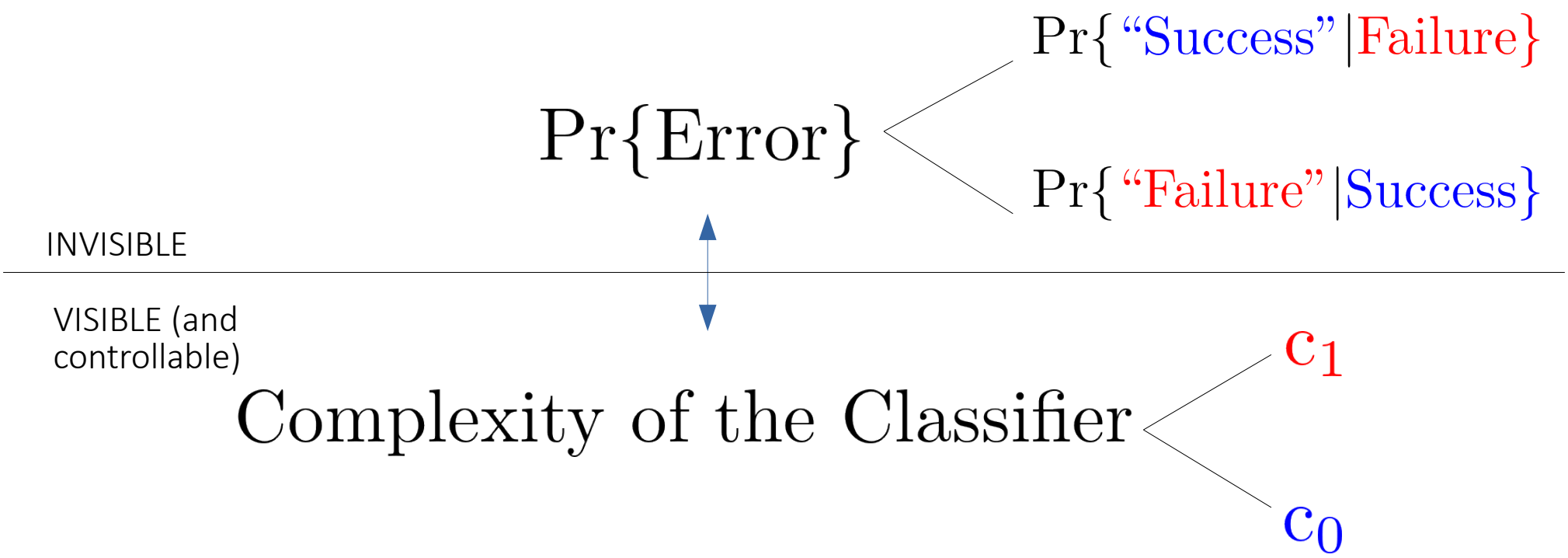


Classification



"A new classification algorithm with guaranteed sensitivity and specificity for medical applications"
A. Carè, F.A. Ramponi, M.C. Campi
IEEE Control Systems Letters. 2(3):393-398, 2018

Ventricular Fibrillation (VF) dataset

VF dataset (15 pos, 155 neg), $\beta = 10^{-2}$			
$c_1 : c_0$	1 : 1	1 : 10	1 : 80
$\mathbf{k}_1 : \mathbf{k}_0$	9 : 9	5 : 41	2 : 90
Sens:*Spec*	11% : 85%	30% : 59%	51% : 28%

Expanded VF dataset (240 pos, 2477 neg), $\beta = 10^{-3}$				
$c_1 : c_0$	1 : 1	1 : 10	1 : 80	1 : 240
$\mathbf{k}_1 : \mathbf{k}_0$	16 : 16	1 : 121	8 : 568	4 : 1055
Sens:*Spec*	84% : 98%	86% : 93%	89% : 73%	92% : 53%

SMOTE (Synthetic Minority Over-sampling Technique)

New lines of research

IDEA: use many guaranteed classifiers simultaneusly and let the majority have the final word.

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FACT: It is possible that the performance of the majority of equally skilled experts is **worse** than the performance of any individual expert!

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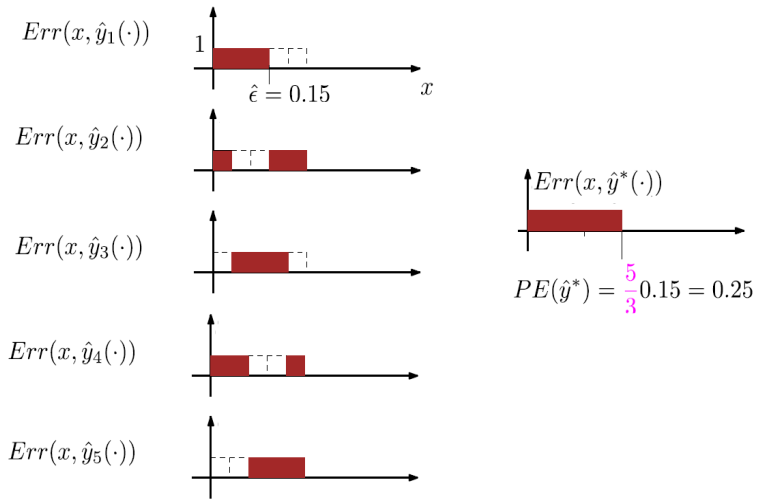
Proof:



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8th IFAC Workshop on Distributed Estimation and Control in Networked Systems
Sept. 16-17, 2019, Chicago, IL, USA.

More info: `https://www.algocare.it/GEM-BALLS/`

Main papers on these topics

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