Controllo di Sistemi Complessi

Roberto Tempo
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IEEE – Institute of Electrical and Electronics Engineers

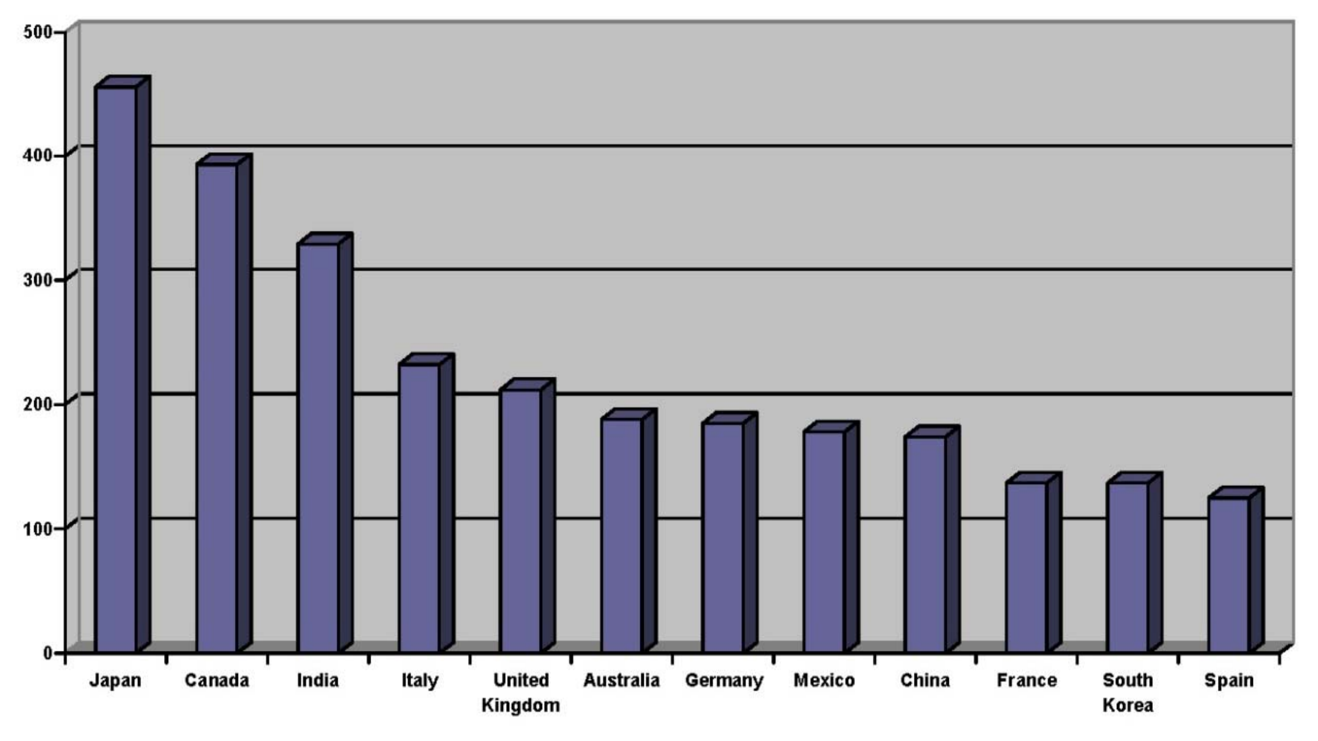
The world’s largest professional association for the advancement of technology

- Costituita nel 1963 dall’unione di American Institute of Electrical Engineers (fondata nel 1884) e da Institute of Radio Engineers (fondata nel 1912)
- 375,000 membri distribuiti in 160 nazioni; 45% dei quali al di fuori degli Stati Uniti

CSS – Control Systems Society

- CSS è una delle 38 Societies of IEEE (8,338 membri)
- Numero di paesi rappresentati: 116
- Membri

  USA: 3,553



R. Tempo
"Internationalization and Globalization"
IEEE Control Systems Magazine, Feb. 2010

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IEEE CSS Transactions and Magazine

IEEE TRANSACTIONS ON
AUTOMATIC CONTROL

A PUBLICATION OF THE IEEE CONTROL SYSTEMS SOCIETY

FEBRUARY 2010 VOLUME 55 NUMBER 2 IETAA9 (ISSN 0018-9286)

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AUTOMATIC CONTROL

A PUBLICATION OF
THE IEEE CONTROL
SYSTEMS SOCIETY

VOLUME 55
JANUARY 2010
NUMBER 1
FEBRUARY 2010
NUMBER 2

IEEE

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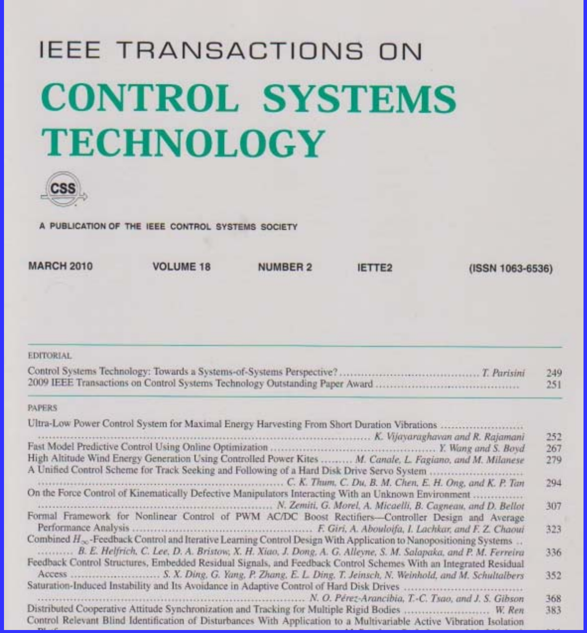

IEEE TRANSACTIONS ON
CONTROL SYSTEMS TECHNOLOGY

A PUBLICATION OF THE IEEE CONTROL SYSTEMS SOCIETY

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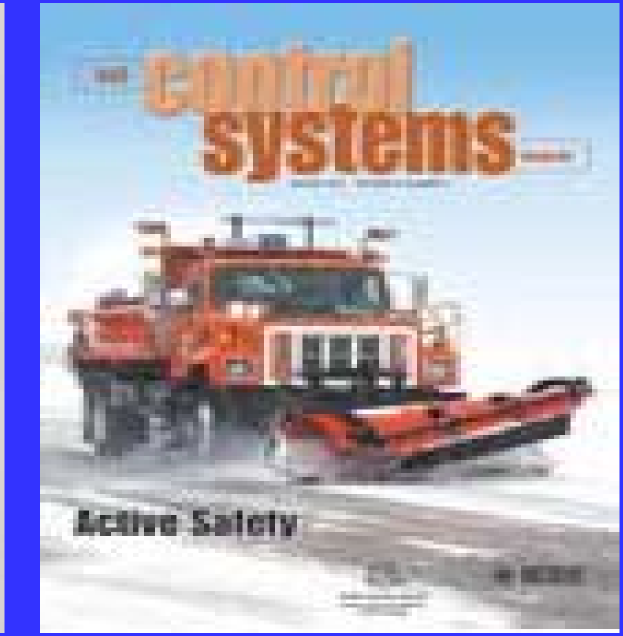

control systems

Active Safety

advancing control science and technology

2010 IEEE CSS Sponsored Conferences

2010 IEEE Multi-Conference on Systems and Control

September 8-10, 2010
Yokohama, a port city on Tokyo Bay
Japan

49th IEEE Conference on Decision and Control

December 15-17, 2010
Atlanta, Georgia, USA

IEEE CSS: Technical Committees - 1

- Aerospace Controls
- Automotive Controls
- Behavioral Systems and Control Theory
- Computational Aspects of Control Systems Design
- Control Education
- Discrete Event Systems
- Distributed Parameter Systems
- Hybrid Systems
- Industrial Process Control
- Intelligent Control

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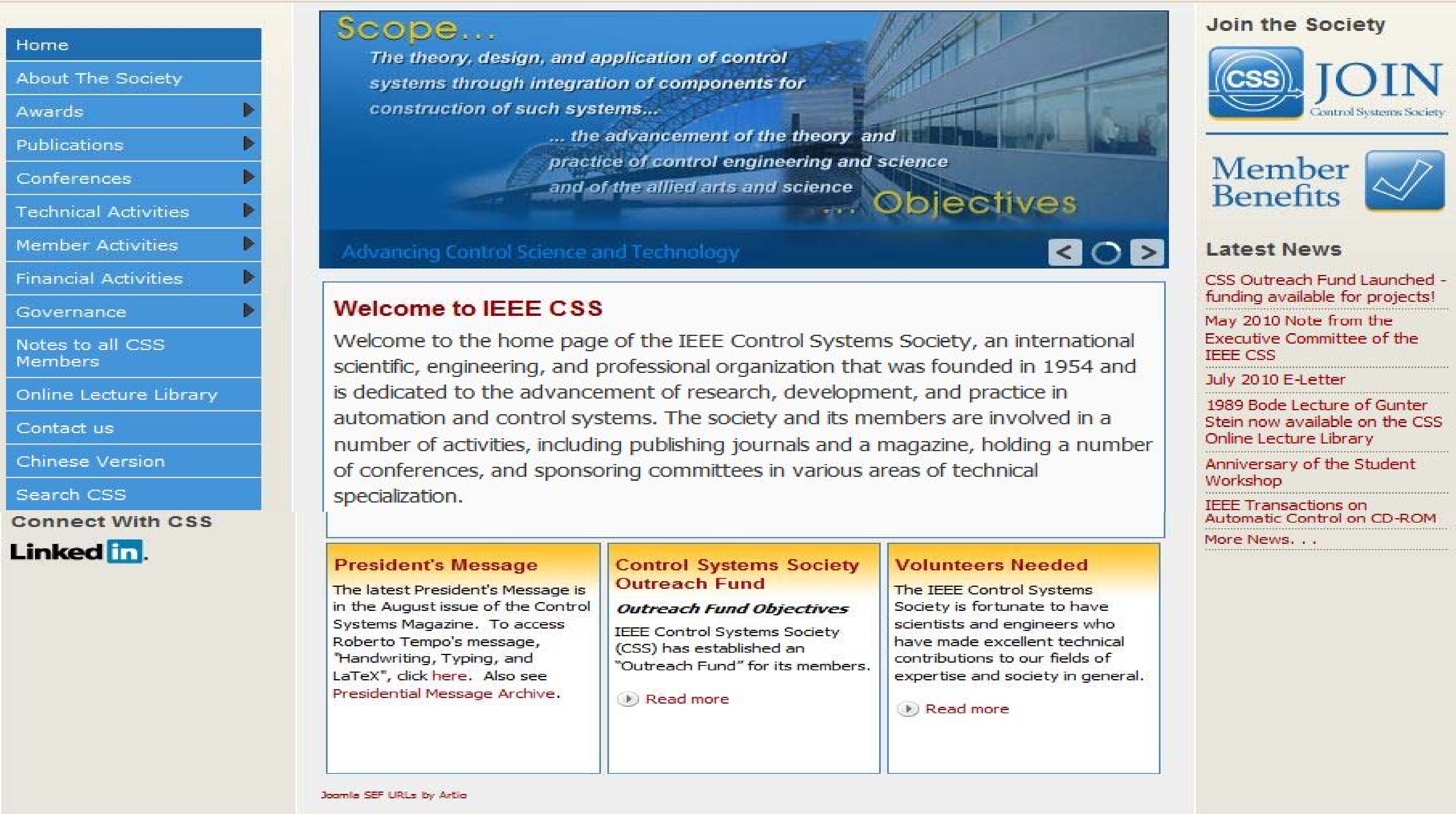
IEEE CSS: Technical Committees - 2

- Manufacturing Automation & Robotic Control
- Networks and Communication Systems
- Nonlinear Systems and Control
- Power Generation
- Smart Grids
- Systems Biology
- Systems ID and Adaptive Control
- Systems with Uncertainty
- Variable Structure and Sliding Mode Control

http://www.ieeecss.org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Advancing Control Science and Technology

Scope...

The theory, design, and application of control systems through integration of components for construction of such systems...

... the advancement of the theory and practice of control engineering and science and of the allied arts and science

... Objectives

Welcome to IEEE CSS

Welcome to the home page of the IEEE Control Systems Society, an international scientific, engineering, and professional organization that was founded in 1954 and is dedicated to the advancement of research, development, and practice in automation and control systems. The society and its members are involved in a number of activities, including publishing journals and a magazine, holding a number of conferences, and sponsoring committees in various areas of technical specialization.

President's Message

The latest President's Message is in the August issue of the Control Systems Magazine. To access Roberto Tempo's message, "Handwriting, Typing, and LaTeX", click here. Also see Presidential Message Archive.

Control Systems Society Outreach Fund

Outreach Fund Objectives

IEEE Control Systems Society (CSS) has established an "Outreach Fund" for its members.

Read more

Volunteers Needed

The IEEE Control Systems Society is fortunate to have scientists and engineers who have made excellent technical contributions to our fields of expertise and society in general.

Read more

Joomla SEF URLs by Artio

Latest News

- CSS Outreach Fund Launched - funding available for projects!
- May 2010 Note from the Executive Committee of the IEEE CSS
- July 2010 E-Letter
- 1989 Bode Lecture of Gunter Stein now available on the CSS Online Lecture Library
- Anniversary of the Student Workshop
- IEEE Transactions on Automatic Control on CD-ROM
- More News. . .

Controllo di Sistemi Complessi

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Sommario

- Controllo di un singolo velivolo autonomo (agente) senza pilota
- Monitoraggio di incendi in Sicilia e di siti archeologici
- Controllo di molti agenti
- Monitoraggio tramite numerosi sensori wireless di affreschi medioevali
- Controllo di sistemi complessi
- Data deluge and obliquity for control

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Velivoli Autonomi senza Pilota (UAVs)

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Monitoraggio e Prevenzione di Incendi mediante UAV

- Progetto Nazionale supportato dal Ministero dell’Istruzione, dell’Università e della Ricerca

Studio e sviluppo di un sistema di controllo e monitoraggio per prevenzione di incendi

- Obiettivi: educational per studenti di ingegneria aeronautica e di ricerca
- Gruppi di ricerca in vari settori (aerospace, *control*, communication, computer engineering) e agenzia governativa per il controllo degli incendi in Sicilia

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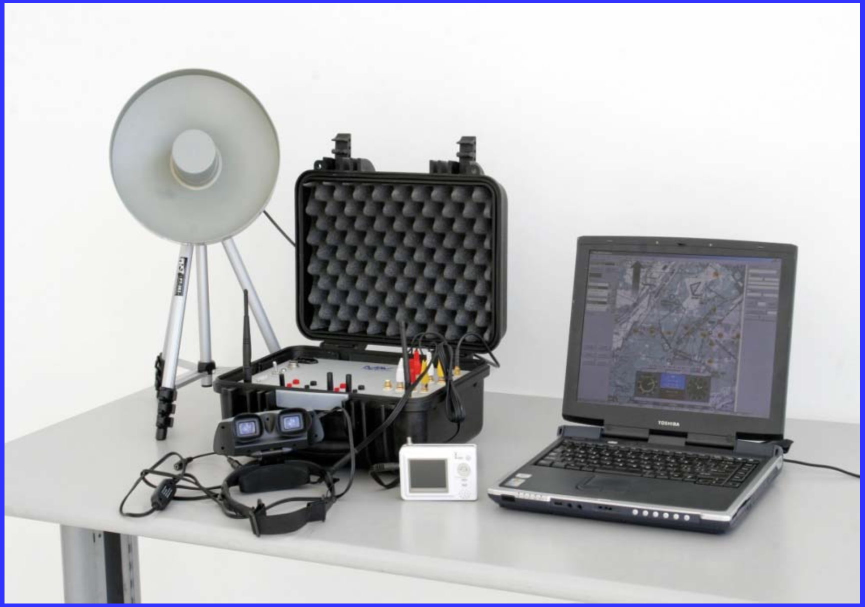
MH1000 Platform - 1

- MH1000
- apertura alare: 1 m; peso: 1.5 Kg

- Stazione a terra
- protocolli di comunicazione/software



Piattaforma aerea basata su configurazione MicroHawk sviluppata presso Dip. Ingegneria Aerospaziale, Politecnico di Torino

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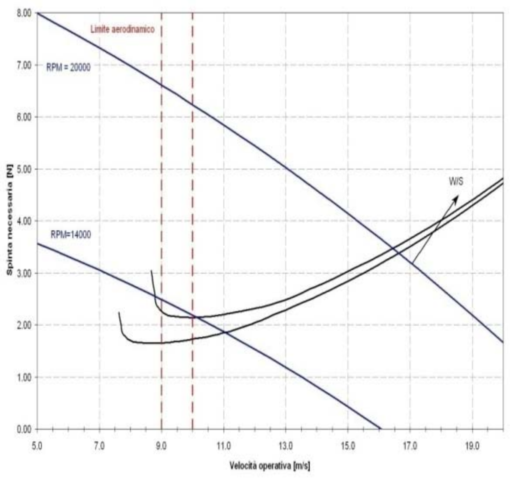
MH1000 Platform - 2

- Equipaggiamento sul velivolo: numerosi sensori e due telecamere (colore e infrarosso)
- Motore DC
- Pilotaggio remoto e volo autonomo
- Durata del volo: 40 minuti
- Inviluppo di volo:
  - velocità min/max: 10 m/s –17 m/s
  - velocità media: 14 m/s



Sistemi a Bordo

DC motor: Hacker B20-15L (4:1)

- weight: 58 g
- dimensions: Ø 20 x 40 mm
- Kv: 3700 rpm/volt

controller: Hacker Master Series 18-B-Flight

- weight: 21 g
- dimensions: 33 x 23 x 7 mm
- current drain: 18 A

battery: Kokam 2000HD (3x)

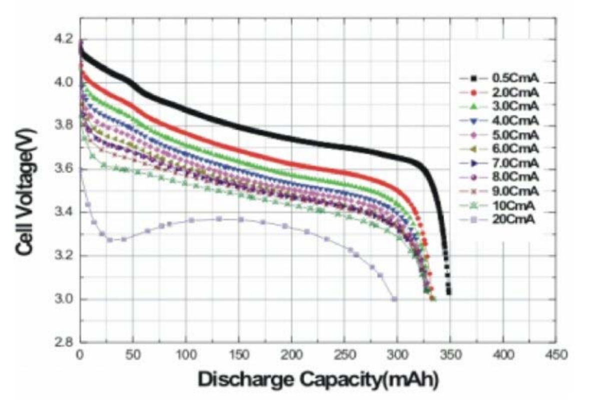
- weight: 160 g
- dimensions: 79 x 42 x 25 mm
- capacity: 2000 mAh

receiver: Schulze Alpha840W

- weight: 13.5 g
- dimensions: 52 x 21 x 13 mm
- 8 channels

servo: Graupner C1081 (2x)

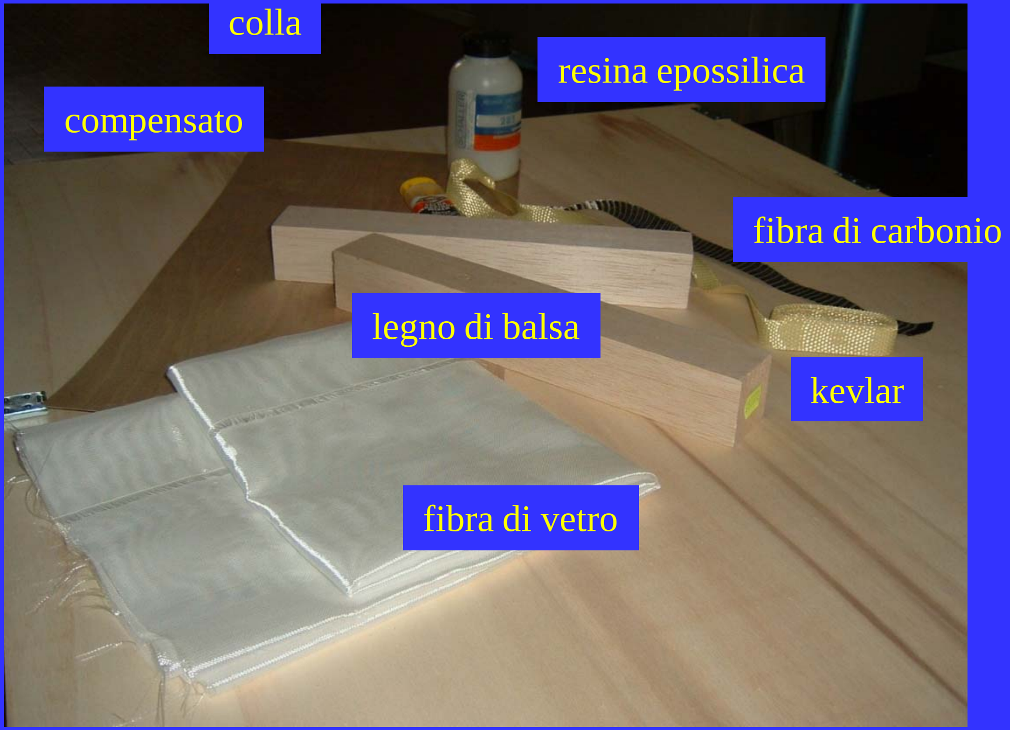
- weight: 13 g
- dimensions: 23 x 9 x 21 mm
- torque: 12 Ncm



Costruzione del Prototipo - 1

materiale grezzo

polistirene


colla
resina epossilica
compensato
fibra di carbonio
legno di balsa
kevlar
fibra di vetro

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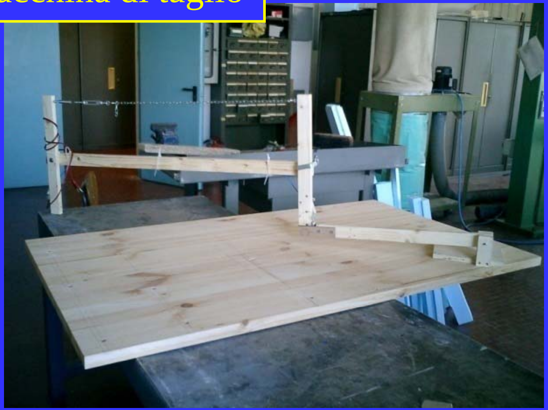
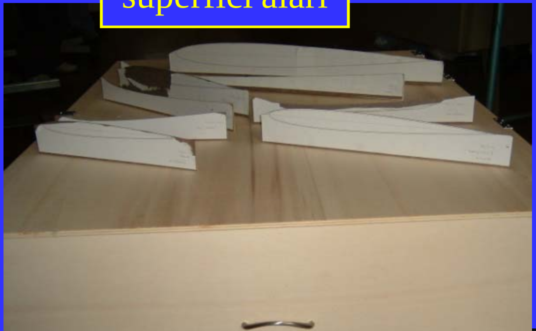
Costruzione del Prototipo - 2

strumenti di lavoro

macchina di taglio



superfici alari



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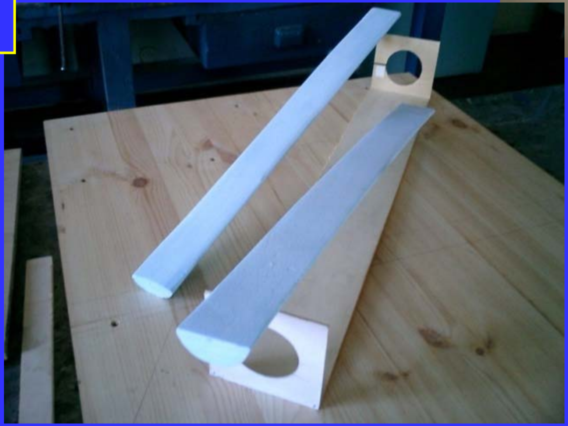

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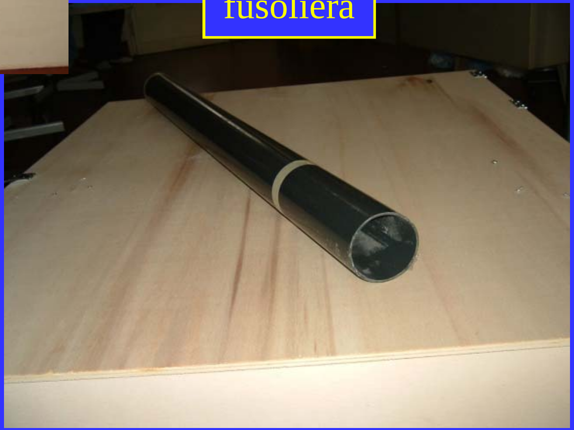

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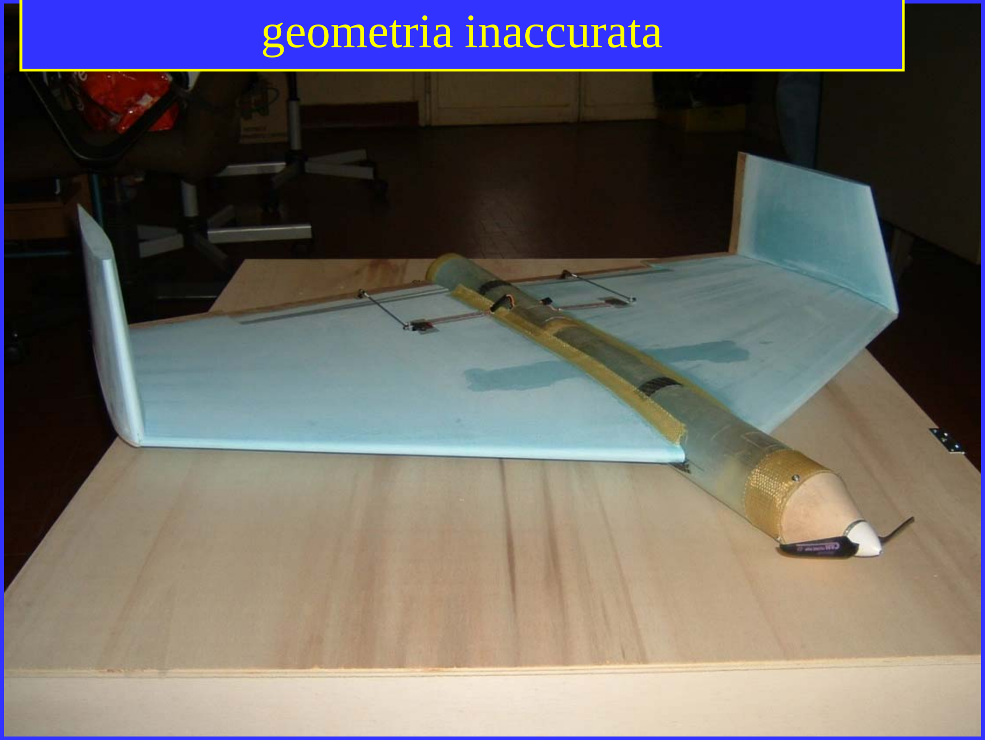
Costruzione del Prototipo - 3

prototipo

facile e rapida costruzione
difficile riproducibilità
geometria inaccurata



Sistema di Controllo

- Stabilizzazione dinamica del piano longitudinale e del piano latero-direzionale
- Stabilità della piattaforma fondamentale per la qualità del video per compiti di sorveglianza e monitoraggio
- Verifica delle prestazione utilizzando specifiche militari
- Caratterizzazione dei parametri incerti mediante modelli parametrici

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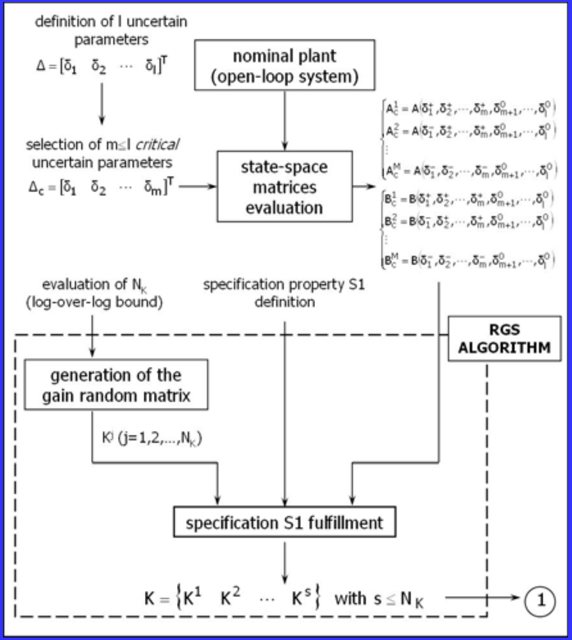
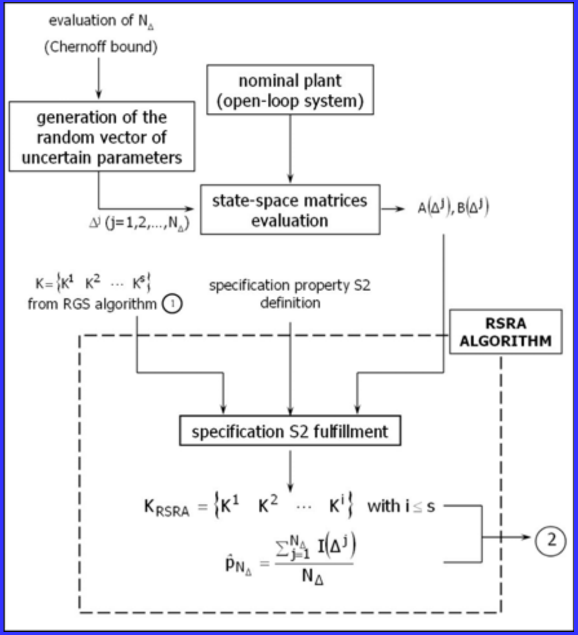
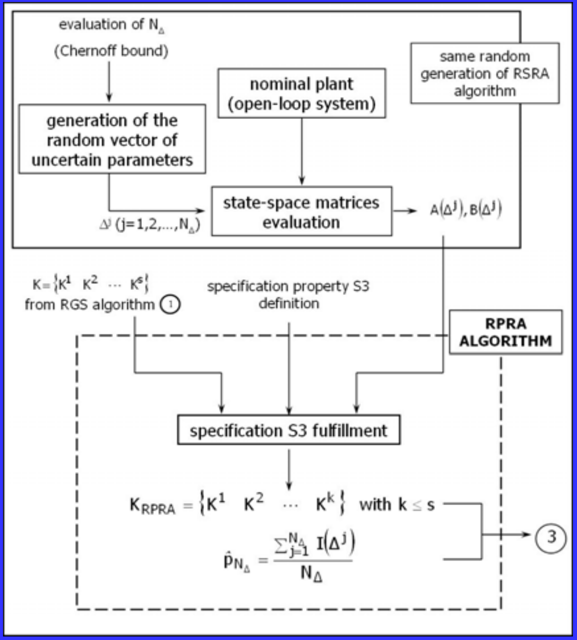
Algoritmi di Controllo per MH-1000[1]

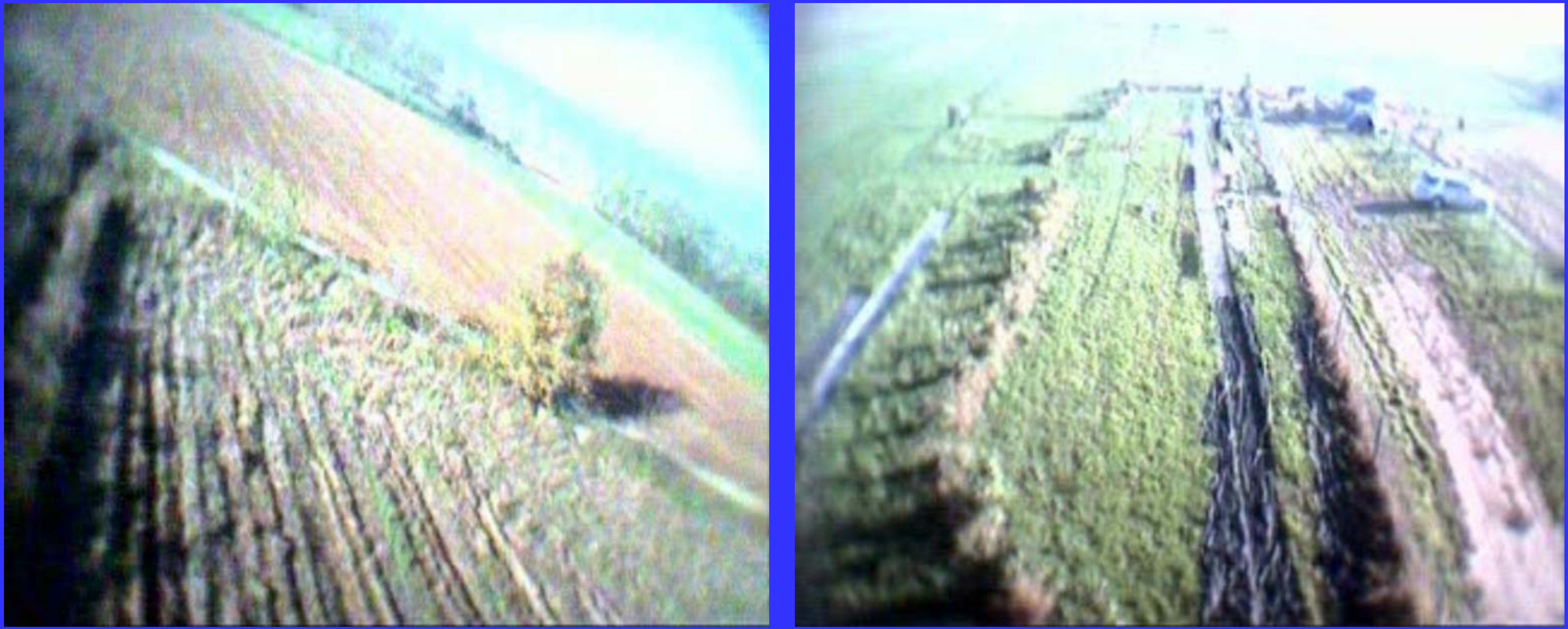

definition of l uncertain parameters
$\Delta = [\delta_1 \quad \delta_2 \quad \cdots \quad \delta_l]^T$
nominal plant (open-loop system)
selection of m≤l *critical* uncertain parameters
$\Delta_c = [\delta_1 \quad \delta_2 \quad \cdots \quad \delta_m]^T$
state-space matrices evaluation
$A_c^1 = A(\delta_1^+, \delta_2^+, \dots, \delta_m^+, \delta_{m+1}^0, \dots, \delta_l^0)$
$A_c^2 = A(\delta_1^-, \delta_2^+, \dots, \delta_m^+, \delta_{m+1}^0, \dots, \delta_l^0)$
$A_c^M = A(\delta_1^-, \delta_2^-, \dots, \delta_m^-, \delta_{m+1}^0, \dots, \delta_l^0)$
$B_c^1 = B(\delta_1^+, \delta_2^+, \dots, \delta_m^+, \delta_{m+1}^0, \dots, \delta_l^0)$
$B_c^2 = B(\delta_1^-, \delta_2^+, \dots, \delta_m^+, \delta_{m+1}^0, \dots, \delta_l^0)$
$B_c^M = B(\delta_1^-, \delta_2^-, \dots, \delta_m^-, \delta_{m+1}^0, \dots, \delta_l^0)$
evaluation of N_K (log-over-log bound)
specification property S1 definition
RGS ALGORITHM
generation of the gain random matrix
K^j $(j=1,2,\dots,N_K)$
specification S1 fulfillment
$K = \{K^1 \quad K^2 \quad \cdots \quad K^s\}$ with $s \le N_K$
①


evaluation of N_Δ (Chernoff bound)
nominal plant (open-loop system)
generation of the random vector of uncertain parameters
state-space matrices evaluation
Δ^j $(j=1,2,\dots,N_\Delta)$
$A(\Delta^j), B(\Delta^j)$
$K = \{K^1 \quad K^2 \quad \cdots \quad K^s\}$ from RGS algorithm ①
specification property S2 definition
RSRA ALGORITHM
specification S2 fulfillment
$K_{RSRA} = \{K^1 \quad K^2 \quad \cdots \quad K^i\}$ with $i \le s$
$\hat{p}_{N_\Delta} = \frac{\sum_{j=1}^{N_\Delta} I(\Delta^j)}{N_\Delta}$
②


evaluation of N_Δ (Chernoff bound)
same random generation of RSRA algorithm
nominal plant (open-loop system)
generation of the random vector of uncertain parameters
state-space matrices evaluation
Δ^j $(j=1,2,\dots,N_\Delta)$
$A(\Delta^j), B(\Delta^j)$
$K = \{K^1 \quad K^2 \quad \cdots \quad K^s\}$ from RGS algorithm ①
specification property S3 definition
RPRA ALGORITHM
specification S3 fulfillment
$K_{RPRA} = \{K^1 \quad K^2 \quad \cdots \quad K^k\}$ with $k \le s$
$\hat{p}_{N_\Delta} = \frac{\sum_{j=1}^{N_\Delta} I(\Delta^j)}{N_\Delta}$
③

[1] L.Lorefice, B. Pralio, R. Tempo, Control Engineering Practice, 2009

Test di Volo in Sicilia



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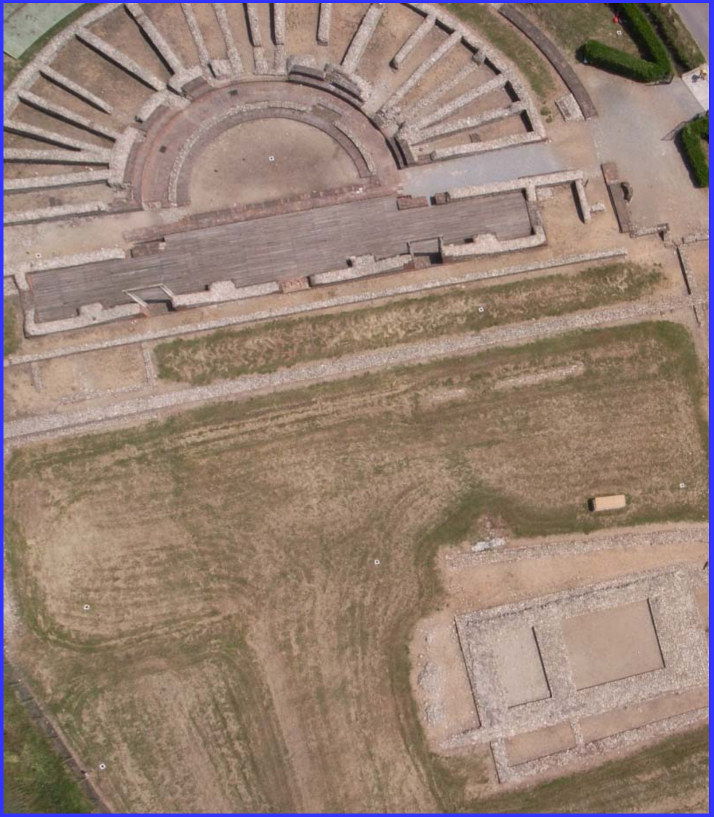
MH-2000: Monitoraggio di Siti Archeologici

- Sito archeologico di Bene Vagienna
- Resti della città romana *“Augusta Bagiennorum”*
- Importante insediamento nel sistema di urbanizzazione e sfruttamento agricolo del Piemonte meridionale da parte dei Romani
- Fondata dall’imperatore Augusto verso la fine del I sec. A.C.



- Teatro, basamento di un tempio, muri perimetriali di una basilica

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MH-2000: Monitoraggio di Siti Archeologici[1]

[1] Archaelogical Site Monitoring, F. Quagliotti and ITHACA (2008)

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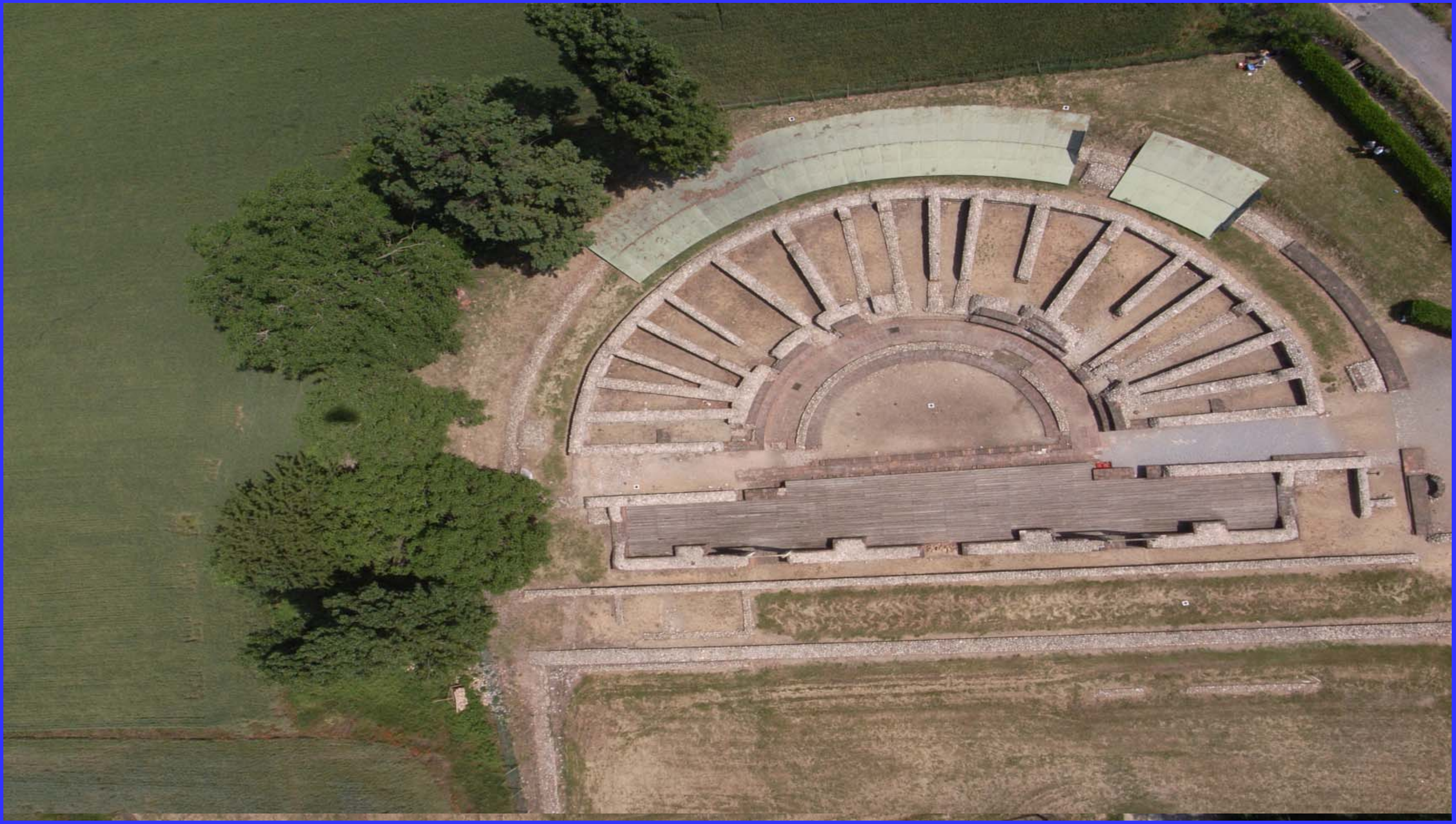
MH-2000: Monitoraggio di Siti Archeologici[1]



[1] Archaelogical Site Monitoring, F. Quagliotti and ITHACA (2008)

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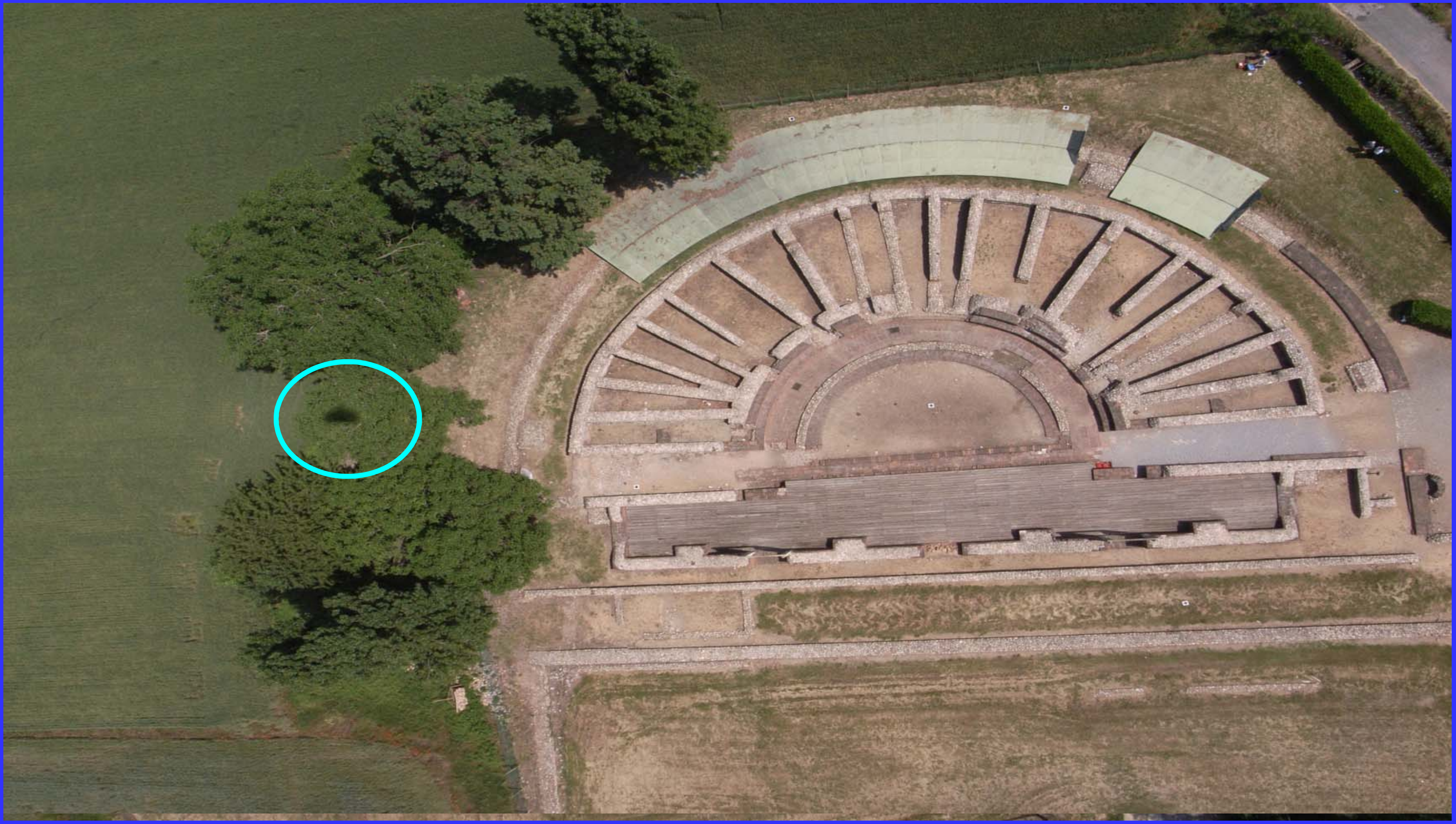
MH-2000: Monitoraggio di Siti Archeologici[1]



[1] Archaelogical Site Monitoring, F. Quagliotti and ITHACA (2008)

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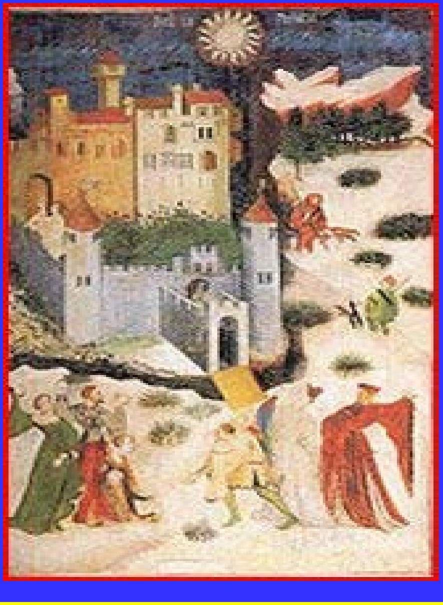
Reti di Sensori e Consenso

Torre Aquila, Trento

- Torre Aquila: alta 31 metri e posta nelle vicinanze del Castello del Buonconsiglio a Trento
- Esempio straordinario di arte gotica
- Gruppo di 11 affreschi detti il "Ciclo dei Mesi" dipinti nel XV secolo da un artista sconosciuto della Boemia
- Per diminuire il traffico, è necessario costruire un tunnel che può creare dannosissime vibrazioni



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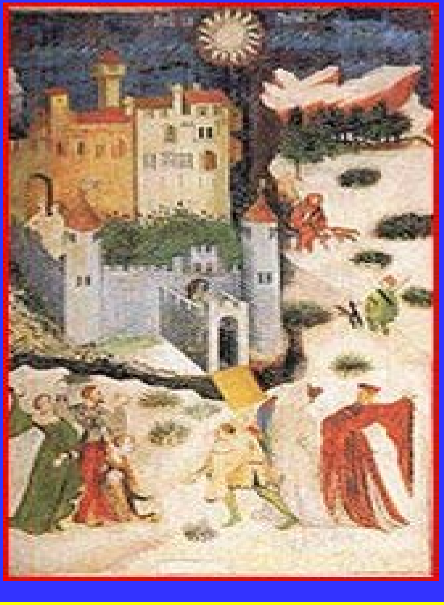
WSN (Wireless Sensor Network) nella Torre Aquila, Trento[1]

- Rete wireless di *sensori ambientali* per misurare temperatura, umidità, luce; sensori di *accelerazione* per verificare deformazioni verticali della torre e scivolamento dei muri
- Raccolta di dati provenienti da sensori eterogenei
- Controllo e consenso di reti di sensori



[1] M. Ceriotti, L. Mottola, G. P. Picco, A. L. Murphy, S. Guna, M. Corrà, M. Pozzi, D. Zonta, P. Zanon (2009)

Controllo di WSN

- SN consiste di un grande numero di dispositivi autonomi ultra-small (sensor nodes)
- Ogni sensore ha una batteria, un processore, e un dispositivo di comunicazione radio short-range
- Per motivi di sicurezza lo scambio di informazioni tra sensori sono criptate
- Chiavi (password) per i dispositivi di criptaggio devono essere concordate tra i sensori (nodi)
- Raggiungere “consenso” tra i sensori è un difficile problema di controllo che richiede algoritmi sofisticati

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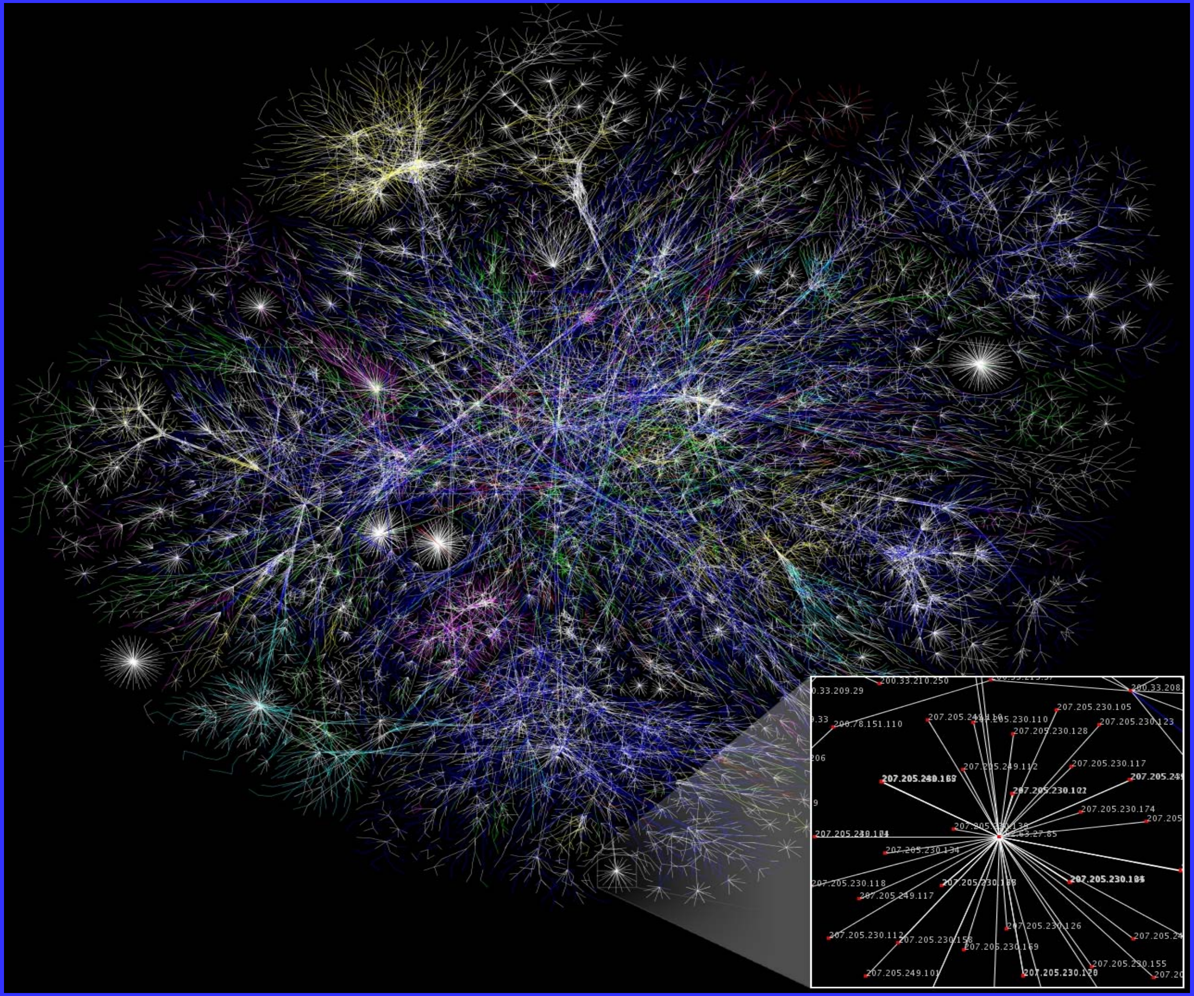
Sistemi Complessi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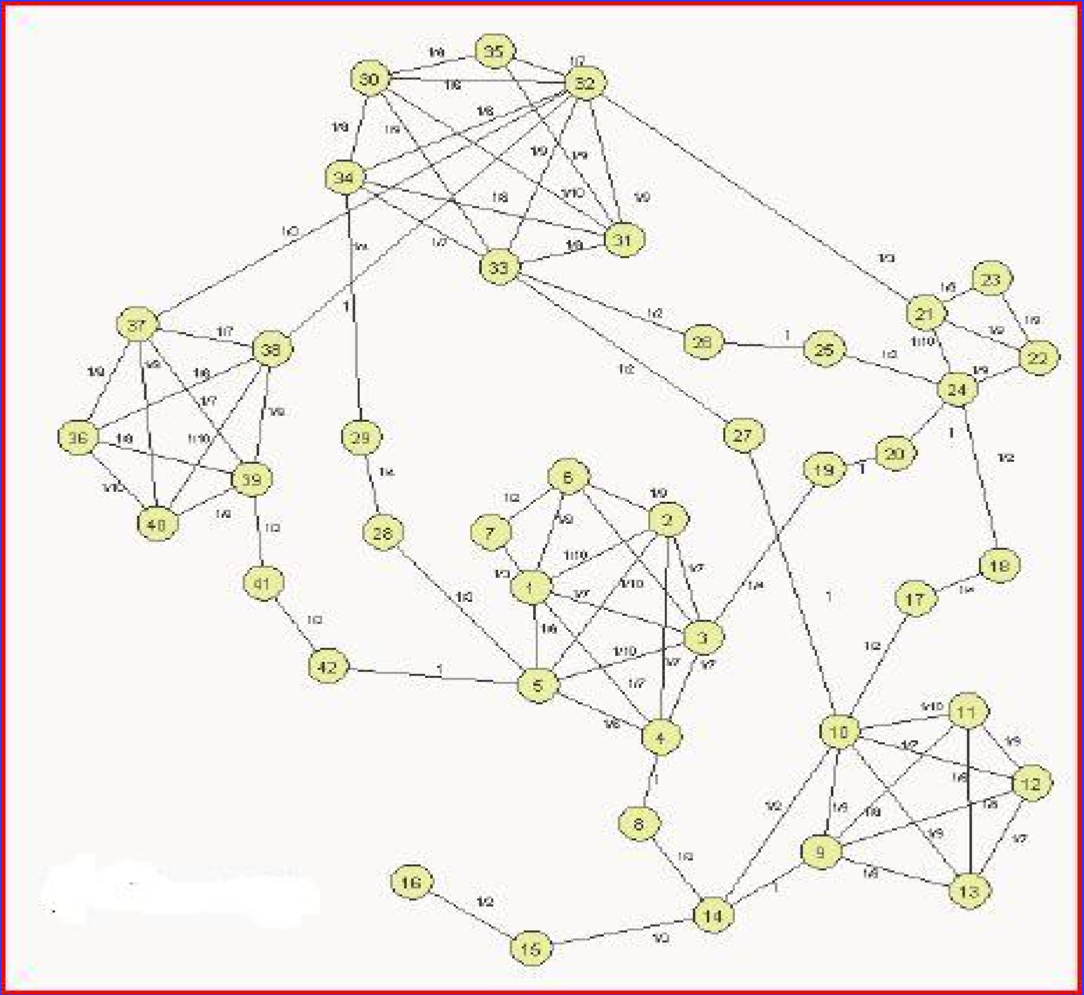
207.205.249.101

sistemi complessi: caratterizzati da un numero esponenziale di *interconnessioni tra agenti autonomi*

esempio: *Internet*

IEIIT-CNR

Sistemi Complessi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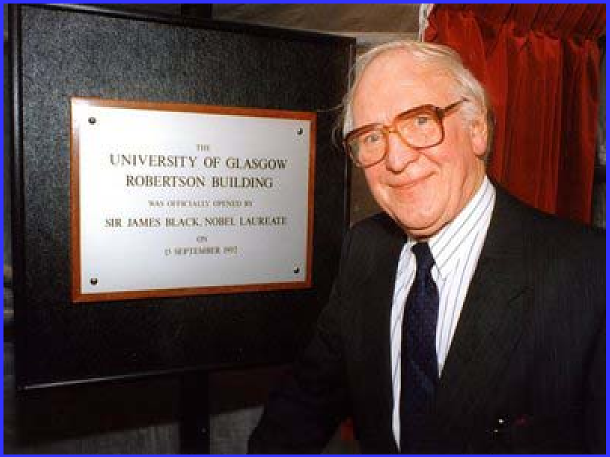
sistemi complessi: *aggregazioni* che dimostrano *emergent behaviors*

esempio: *social networks*

facebook
2
2
Roberto Tempo

Obliquity and Complex Systems

- Concetto di *obliquity* coniato da Sir *James W. Black*, medico e farmacologo Scozzese
- Nobel Prize for Medicine in 1988
- Concetto generalizzato ed esteso all’economia da John Kay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UNIVERSITY OF GLASGOW
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ON

Obliquity is the act of reaching a goal through indirect, rather than direct, means

Obliquity per il Controllo di Sistemi Complessi[1]

- Nessun evento futuro o azione può essere determinata mediante un approccio diretto che richiede un numero esorbitante di calcoli (complessità computazionale)
- Legami tra obliquity e la teoria del chaos sono stati studiati dai fisici
- Molti esempi di *obliquity* nell'area dei controlli

MPC, receding horizon, adaptive control, dynamic programming, sequential on-line optimization

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[1] R. Tempo, IEEE Control Systems Magazine, 2010

Conclusioni

❖ La sfida del prossimo decennio

dal controllo del singolo agente (UAV) e di reti di sensori al controllo di sistemi complessi caratterizzati da un numero esponenziale di interconnessioni tra agenti autonomi