H2CU Magazine Spring 2014

H2CU Mag - Spring 2014

by
Maria Grillo, H2CU Coordinator in New York,
Maurizio Porfiri, NYU Polytechnic School of Engineering,
Salvatore Grimaldi, Secretary of H2CU Center.

Contents

2013 Year of Italian Culture in the US

In 2013, the "Year of Italian Culture in the United States" was celebrated in the US, a year of events organized by the Ministry of Foreign Affairs. The H2CU was included in the official calendar of events for this celebration. Thus, the Center has organized several events in Rome and the US, launching the H2CU Magazine - Special Issue to celebrate all the activities developed by the H2CU in its 10 years of activity. On February 4 2013, the H2CU has organized a workshop at "Sapienza" University of Rome on "Italy and the US: strategy for joint academic collaborations" with the collaboration of the Fondazione Roma Sapienza and the Italy-USA Foundation. During this workshop the initiatives promoted by the Center for Year of Italian Culture in the United States were presented, including activities held in Miami in February 2013 and New York in May 2013. This workshop focused on the importance of internationalization and the role of international joint academic programs with US Universities.

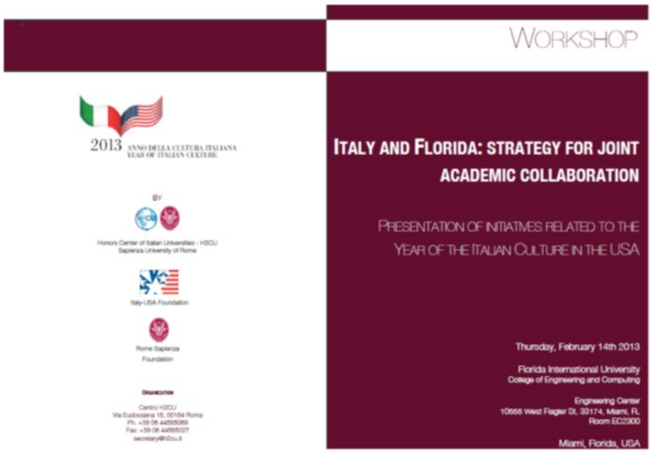
Brochure of the workshop of February 4, 2013 "Italy and USA: strategy for joint academic collaborations"

The workshop has seen the participation of Lucio Ubertini, Director of the H2CU Center, Lucio D' Ubaldo, President of the Italy-USA Foundation, Antonello Biagini, Vice Rector for International Relations and Cooperation of Sapienza University of Rome, Ornella Flore, Scientific Advisor of the Italian Cultural Institute of New York, Franco Laponcello, President of John Cabot University, and Maria Grazia Quieti, Executive Director of the US- Italy Fulbright Commission. Paolo Cappa and Laura Moscati from Sapienza, Maura Imbimbo from University of Cassino, and Marco Savoia from University of Bologna have also attended the workshop to present selected joint academic programs with US University partners in New York City, namely, New York University and Columbia.

The workshop "Italy and Florida: Strategy for joint academic collaboration" held in Miami was the opening event of a series of activities organized in Miami by H2CU, in collaboration with FIU - Florida International University and with the support of the Consul General of Italy in Miami Adolfo Barattolo. FIU- Florida International University hosted two workshops on February 14 and 15, the first at the College of Engineering and Computer Science and the second at the College of Arts and Science.

During these workshops, the Italian delegation, led by Lucio Ubertini, had the opportunity to discuss possible activities to promote the establishment of joint academic programs between FIU and Italian Universities, associated with H2CU, reinforcing the Memorandum of Understanding signed by H2CU and FIU in 2012.

During the visit in Miami, the Italian delegation also met with representatives of the University of Miami and Miami Dade College and the H2CU programs developed over the years in New York and Boston were discussed to lay the foundation for possible future collaborations. Following this fruitful discussion, H2CU signed a Memorandum of Understanding with the University of Miami on December 13,



Brochure of the Workshop of February 14, 2013 "Italy and USA: strategy for joint academic collaborations"

2013, at the presence of the President of University of Miami, Donna E. Shalala, Antonio Nanni, University of Miami, and the Italian General Consul, Adolfo Barattolo.

On May 16 and 17 2013, the H2CU has organized two events in New York City; the first event was held at the Consulate General of Italy and the second was held at the Italian Cultural Institute of New York City. The event "Italian American Cultural Relationship in a Changing World" was held on May 16 with the special participation of Mrs. Matilda Cuomo, founder of the Mentoring USA program, and the Consul General of Italy, Natalia Quintavalle. A round table in which distinguished guests discussed the future of H2CU initiatives was part of the event with the goal of increasing the synergies between the Italian and the US Academy. The round table was chaired by David Caputo, President Emeritus of PACE University, and featured Katepalli Sreenivasan, Dean of NYU Polytechnic School of Engineering, Stephen Friedman, President of PACE University, and Lucio Ubertini, along with numerous representatives of Italian and US academy. The workshop saw the participation of several H2CU students and alumni. During the event, Lucio Ubertini has awarded the distinguished guests the commemorative medals of the event.

The event on May 17, held at the Italian Cultural Institute of New York and entitled "H2CU Highlights in New York", was a workshop dedicated to H2CU students and alumni. During the workshop, students and alumni presented their H2CU-sponsored experience and research in New York. The event was chaired by Lucio Ubertini and Ornella Flore,

Brochure of the Workshop of May 16, 2013 “Italian American Cultural Relationship in a Changing World”

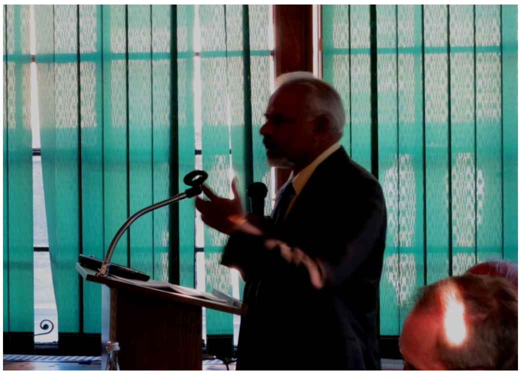
(from the left) Adolfo Barattolo, Donna E. Shalala, Lucio Ubertini, during the signature of the MOU between H2CU and University of Miami

Scientific Advisor of the Italian Cultural Institute. The event was divided into two parts: the first part presented by Prof. Maurizio Porfiri consisted of the presentation of students’ research, which is part of this issue of the H2CU Magazine, while the second part, presented by Prof. Salvatore Grimaldi, allowed selected alumni to share their experience in NY, also featured in the H2CU Magazine. During the workshop, Lucio Ubertini and Victor Goldsmith, Provost of PACE University, awarded H2CU students and Alumni with the H2CU Medal and the H2CU Certificate of Appreciation.

Adolfo Barattolo and Lucio Ubertini in Miami February 2013

Brochure of the Workshop of May 17, 2013 “H2CU Highlights in New York”

Group picture in Miami during the H2CU trip on February 2013



Picture 1: Stephen Friedman, David Caputo, Matilda Cuomo, Natalia Quintavalle, Lucio Ubertini and Katepalli Sreenivasan; Picture 2: participant at the workshop of May 16, 2013; Picture 3: David Caputo and Stephen Friedman; Picture 4: Katepalli Sreenivasan

Picture 1: Lucio Ubertini and Ornella Flore; Picture 2: Lucio Ubertini, Victor Goldsmith and Paolo Cappa; Picture 3: Lucio Ubertini, Victor Goldsmith and Stefano Pacifico, H2CU Alumni; Picture 4: Lucio Ubertini, Victor Goldsmith and Enrica Oliva, H2CU Alumni

"H2CU, College Italia, Italian Universities: ten years of Internationalizzation"

Interview with Dr. Antonello Masia

New York City, May 1, 2013

by Francesca Lorusso Caputi and Maria Grillo

Francesca: **How was the idea of the College Italia born?**
Masia: The project College Italia was born during a meeting I had with Prof. Lucio Ubertini, in which this idea emerged. Initially, Prof. Ubertini had thought to create a consortium of Italian universities in New York. Working on this idea, we identified the primary objective of this initiative, that is, to offer students, graduates, researchers and professors a structure, aiding in logistical and academic issues. Following the proposal of Prof. Ubertini, I organized a meeting with the Italian Minister of Education, at the time Mrs. Letizia Moratti, who liked the project and began to conceive the steps that were needed to develop an initiative of this kind.

Francesca: **From here, the H2CU Center was established**:
Masia: At the beginning, the idea was to establish University consortium. Later, this notion was reconsidered toward the acquisition of space for students, researchers and professors to enhance their academic and scientific exchanges with US partner institutions. The purchase of apartments was the solution we found and through the Italian Ministry (MIUR) we took charge of the majority of the costs and we sought to identify a group of universities interested in the project that were willing to cover the remaining amount. We contacted many University Presidents, and we found a significant acceptance. The process was not easy, especially for what concerned the evaluation of the project, and the provision of financial resources. During fruitful discussions with Prof. Ubertini, we thought of establishing an Inter-University Center for International Education H2CU, with Sapienza University of being the promoter and coordinator. At that point, Sapienza and the other universities shared the expenses, each according to their own resources. Prof. Ubertini was commissioned to find the structure in NY. We must remember that this initiative started in 2006-2007, when the financial situation was favorable and the real estate market of New York had collapsed. The purchase was then possible. When the project was completed in 2008, other universities were ready to join the project.

Francesca: There was a will of Internationalization from these six universities that have decided to pursue this route.
Masia: The XIV Legislation, under the Ministry of Letizia Moratti, was a period in which the implementation of cooperation and relationship with European Universities, South American Universities, North American Universities, and the Universities in the Mediterranean region was pushed. When we proposed the project "College Italia", Minister Moratti was delighted to tie her name to the initiative. When the properties were inaugurated in 2008, Letizia Moratti was the Mayor of Milan, and I personally informed her that the project was finally realized. I recalled she was really happy of the result.

Francesca: What can we say more in general in relation to cooperation and internationalization of the Italian Universities?
Masia: The project College Italia in the US was not the only project that the Ministry was pursuing at that time. There were programs with Argentina and the institution of a University in Istanbul and Egypt were promoted at that time. The idea of the College Italia led to many other projects of cooperation.

Francesca: Have the Italian Universities internationalized?
Masia: We can say that from the '90s the concept of internationalization was greatly enhanced due to the availability of funds and resources mainly toward universities. For example, the Ministry of Education had created several laboratories shared with the US and South America. There were initiative not only to support students abroad, but also researchers and professors. It has been a challenge, but that has paid off; the level of internationalization has increased enough, but it is still lacking. Our programs of study must necessarily take into consideration the possibility for students to spend a semester or more abroad.
The relationships with the US are fervid due to the initiative of some universities. However, there is not a cooperative agreement with the US for the ratification of the equivalence of our degrees at present. This is critical toward establishing Joint Degrees, which would ideally complement the existing double degree programs.

Francesca: The students need to have the conditions and the opportunity to be able to go abroad, to have an experience of study and research in another country.
Masia: It must be said that while professors and researchers can always find ways to cooperate and collaborate, student may face significance challenges. They need to be guided, taken by the hand, from the beginning, otherwise, they may get lost. As I said before, the study abroad experience should be institutionalized, and the student, either undergraduate or graduate, must spend at least 6 months abroad. In fact, this is the spirit of the Erasmus program in Europe, where things are quite simpler. To support such a program, at MIUR we have promoted initiatives to favor student mobility, for example, by increasing the Erasmus scholarships by 50%.

Francesca: Internationalization one-way? Only Italian students go abroad? Or also vice-versa?
Masia: Certainly, the number of Italian students traveling to the US is far larger than the number of US students in Italy. Attracting foreign students in Italy is a much more complicated matter, since we do not have well developed academic infrastructure, for example to facilitate housing.
Said that, the Universita' di Roma Tre has started an interna-

tional office that to facilitate finding accommodations in Rome. Thus, the university seeks housing that are in neighboring areas, which can be made available to students at a low rent. Even if this is a rather sporadic activity, other universities are moving in the same direction to enhance the involvement of foreign students.

Francesca: In recent years, some Italian universities have decided to start degree programs entirely in English; how do these initiatives fit with internationalization?
Masia: When the new programs 3+2 were started in 1998-99, the Bocconi University in Milan was one of the first to offer university courses in English; they started by only giving an English title to a course at the Faculty of Economics, and then they decided to offer the course entirely in English. From the beginning I have supported this initiative; this is "a gap" for our universities that we have to fill; this is an important concept because the English language is a vehicular language and one has to accept this kind of challenge.

Francesca: Italian Universities that have the dual degree programs with US. Universities, in particular with Universities in NYC, should be able to attract foreign students; these are programs established to be bi-directional, yet they are only one-way programs at the moment.
Masia: In 2008, some Italian Universities like Pavia, Milano, Tor Vergata in Rome, established a Graduate Degree in Medicine (Laurea) completely in English. Yet, this does not mean that these universities had courses offered only in English, since they also offered courses in Italian. Likely, this approach can attract foreign students. We need to remember that the possibility of studying abroad was one of the objectives of the Bologna Declaration in 1999 and it is important to continue this conversation.
(Space for Higher Education Bologna June 18-19, 1999; http://www.miur.it/0002Univer/0052Cooper/0064Accord/0335Docume/1385Dichia_cf2.htm)

Francesca: What projects can be started to help universities to become more international?
Masia: At MIUR, we have always thought about internationalization initiatives, and in 2003 I promoted The Conference of the Directors General of the European Union, where the theme of the internationalization was central to the event. The conference was also organized to understand how our European partners have acted on the theme of internationalization. Internationalization is one of the point in which a university is evaluated in international rankings. In this context, the presence of international professors, as in the US and South-East Asia, is extremely important. In these Universities, you can indeed find an international environment, which we cannot witness in Italy.
With respect to future projects, I think that it is now the time to go back to the original idea of Prof. Ubertini, that is, to establish a consortium of Italian universities in NYC. Based on this very positive experience, we should revisit the original project, which could be instrumental in promote our universities and attract foreign students. To achieve this goal, we would not need a substantial investment, and each university should take the lead in promoting its own unique educational or scientific mission This is what was partly realized in Argentina between the University of Buenos Aires and the University of Bologna within their joint initiatives in 2003-2004.
I will support an educational center with the collaboration of different universities, where each institution places the best of their academic and scientific experience and research. I am positive that Prof. Ubertini will not give up, since both of us firmly believe in this project.

Structural identification by means of induced vibrations

Benedetto Argento[1-2-3]

[1]*Department of Civil Engineering and Engineering Mechanics, Columbia University, New York, NY*
[2]*Dipartimento di Ingegneria civile, chimica, ambientale e dei Materiali - DICAM University of Bologna, Bologna, Italy*
[3]*Currently working at Thornton Tomasetti, 51 Madison Avenue New York, NY ba2399@columbia.edu*

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Structural identification
Instrumentation location
Real eigendata.

Abstract

This work is a brief description of the research activity in the field of structural identification performed at Columbia University under the supervision of Professor Raimondo Betti, Professor Francesco Ubertini and Suparno Mukhopadhyay. After a short introduction to the problem of Structural Identification, a new method for determining the optimal instrumentation location in a structural identification scenario is presented. The approach is based on evaluating the error produced in a missing mode response analysis. Building on this concept, "sensitivity parameters" are introduced to inform the strategic actuator/sensor placement. A brief introduction on new relations that allow the conversion from complex to real eigendata is also presented. The formulation is general and can be applied to a real case of structural identification, where complex frequencies and modeshapes are determined by a traditional ERA/OKID approach. A cue about related further developments is provided. The present discussion has been voluntarily minimized in its mathematical and technical essence, although in nature it is.

1. Introduction

The *stubborn* complexity reached today by the design in the civil engineering field keeps increasing the level of quality requirements related to the structural behavior predictions. This need is strictly correlated to the creation of models that accurately represent the real operating conditions of the system by suitable assumptions on mass, stiffness, constraints and materials. The importance of a model in *our* sector is fathomless. In general, in fact, there is no opportunity of scaled reproduction of the designed items like in the manufacturing sector, the only way to understand the behavior of a system is to create a model of it. Making reality a discrete system is never easy, it needs breakdown and selection processes identified by a strong sensibility related to what it is important to catch. In the last decades the awareness related to the uncertainties influencing the mentioned process, joined with the need of monitoring constructed systems, has led to give growing importance to observations and use of experimental response data to validate and update structural models making them very similar to the real systems.

Structural identification (SI) is the process of developing a model that depends on a finite numbers of parameters (usually, a Finite Element Model) and identifying these parameters by a series of cyclic updating stages, exploiting experimental data collection. This updating can involve static or dynamic testing, from which experimental eigendata are extracted and successively compared against numerical ones to validate the model. Acquiring empirical eigendata requires expensive and complex experiences, it is important to strategically plan them to get complete information. One of the most common validation techniques that have been developed is the *Minimal Realization*. Within this framework, a state space model is synthesized to represent the input-output relations of a given system by employing only a minimum number of states: solving a Minimal Realization problem is thus equivalent to identifying the dynamic matrix that constitutes the state space formulation of the system.

Control and observation of structures through a set of strategically located actuators and sensors is a very powerful tool to identify sudden or progressive damage and to estimate the service performance of the system during specific conditions. In order to perform an identification, a set of actuators and sensors (a/s) must be placed on the structure to excite and record its response. The analysis of excitation and response time histories allows, under certain conditions and constraints, to get the system's eigendata. However, this technique generally suffers from two major limitations. The former is related to equipment limitation: usually it is neither feasible nor desirable to place a pair of a/s at each degree of freedom (DOF) of the system; therefore, the engineer must choose where to optimally locate a limited number of instruments. Additionally, the eigendata obtained from the identification are complex-valued and, in order to have a direct physical meaning, should be converted into corresponding real data. The latter problem is addressed by the formulation of new general relations detailed in Section IV.

2. Procedures and Results

The problem of instrument location is a common issue in structural identification, and a systematic procedure capable of suggesting the strategic placement, maximizing the data collection, is a powerful tool. In general two issues are addressed: (i) the problem of global identifiability (i.e. a/s placement to ensure the uniqueness of the indentified system), widely discussed in [1], [2], [3] and [4]; (ii) the problem of optimal instrumentation (i.e. strategic devices location to collect the maximum information), for which interesting approaches are proposed in [5] and [6]. In general, an investigation into the second issue should follow the investigation into the first one: once a set of instrumentation set-ups satisfying global or local identifiability has been obtained, the one providing the maximum information should be detected. The procedure hereafter reported addresses the second issue: where to put the a/s to obtain the *maximum modal information*. In the paper by Udwaida [5] this purpose is achieved by maximizing the Fisher information matrix, while in the paper by Papadimitriou [6] a method to minimize the Information Entropy using a nominal finite element model is defined. In the present study, it is investigated the viability of an alternative strategy, which aims at maximizing the modal information with respect to different instrumentation set-ups. In order to build such a procedure, a preliminary study of the influence of missing modes on the system response has been performed (always conducted by assuming just a pair of a/s each time on a single DOF, with known input and output). The analysis was based on the response's difference between modal models built with complete modeshape knowledge and deficient ones. This difference can be thought as the error induced by the absence of a certain mode in the reconstruction of the system's response through modal superposition. In the proposed method, the error at each DOF has been estimated through a statistical analysis. The results have confirmed the following empirical relation, which can also be obtained using mathematical derivations. Given a response history (acceleration – velocity – displacement) reconstructed by *neglecting j-th* Modeshape, the error produced in the response of DOF i is proportional to the value assumed by the *(i,j)-th* component of the modeshape matrix

$$\frac{error\ dof_i}{modeshape_j\big|_{dof_i}} = constant \quad \forall\, i \qquad (1)$$

In particular, the factor of proportionality is the modal response function at each time (keeping in mind that the error is function of time too) related to the *j-th* missing mode. From this relation, and exploiting the theory of Random Processes (for a detailed discussion see the studies performed in [7], [8] and [9]), it is possible to derive the analytical expression of the variance of this error as a function of the power spectra of the force, the damping coefficient and the frequency of the corresponding missing mode. The variance of the error corresponding to neglecting one specific mode, is then normalized with $\alpha_{i,k}$ the variance of the error corresponding to "neglecting all the modes" (100% error) to obtain an index which quantifies the effect of missing a particular mode against missing the others (by mutual comparison). Let us indicate with the first sensitivity parameter which denotes the effect, in a normalized sense, of neglecting mode k on the response at DOF i. Thus, a smaller $\alpha_{i,k}$ identifies a smaller participation of mode k on the response at DOF i.

Exploiting the same way of reasoning, a sensitivity factor that accounts for all the modes influence at a given DOF i can be defined by estimating the geometric mean of all the $\alpha_{i,k}$'s. Let us indicate this factor with β_i. For a given actuator placement scenario, β_i identifies the sensitivity of the response of DOF i to all the N modes. The lower this factor, the worse a sensor location at DOF i is. For further details refer to [8] and [9].

3. Discussion

In a real case scenario, with an available finite element model of a system, knowing all the related modal parameters, and defining the power spectra of a reasonable white noise, it is relatively straightforward to compute the α's indices for all the DOFS of the system and for all the modeshapes. At this point, by fixing a value of k to study a mode of interest, it is possible to select the largest value of $\alpha_{i,k}$ and place the couple of a/s at the corresponding DOF i. Similarly, if the objective is to capture the overall system behavior, analysis of the β's indices informs the optimal instrumentation location.

For example, when comparing two DOFS i_1 and i_2, $\alpha_{i1,k} < \alpha_{i2,k}$ suggests that the response of DOF i_1 is less sensitive to mode k than the response of DOF i_2. In order to identify mode k, it is therefore desirable to collocate sensor at DOF i_2 instead of DOF i_1, since mode k affects the response of DOF i_2 "more" than the response of DOF i_1. In other words, mode k participates (relatively) more to the response of DOF i_2 than to the response of DOF i_1.

In order to validate this approach, seven degrees of freedom models have been chosen to simulate the behavior of the $\alpha_{i,k}$ and β_i parameters. Monte Carlo simulations have been used to estimate the sensitivity coefficients, considering realizations from model parameter distributions with large standard deviations with respect to the nominal model. The statistics of these estimated sensitivity coefficients reflect the modal information content, and the model uncertainty induces variability in this information. Consistently with our approach to the definition of sensitivity parameters, the pairs of actuator and sensor have been located at one DOF for each simulation.

Inspection of the β_i distributions allows to identify optimal placement for the a/s pair when capturing the overall behavior is of interest. Looking at Figure 1 it is easy to notice

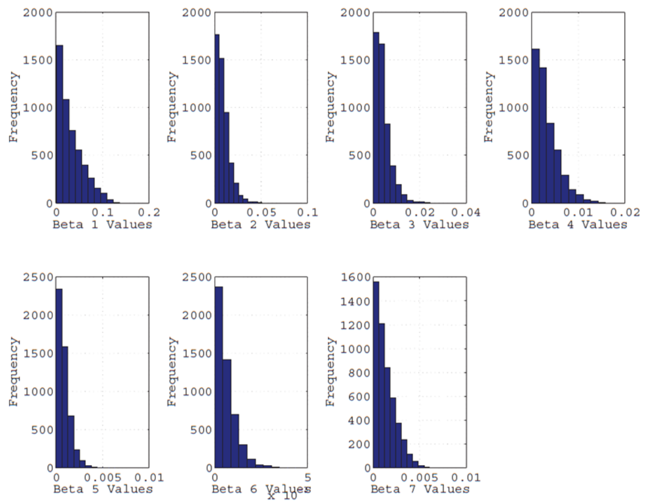

Figure 1: β_i distributions.

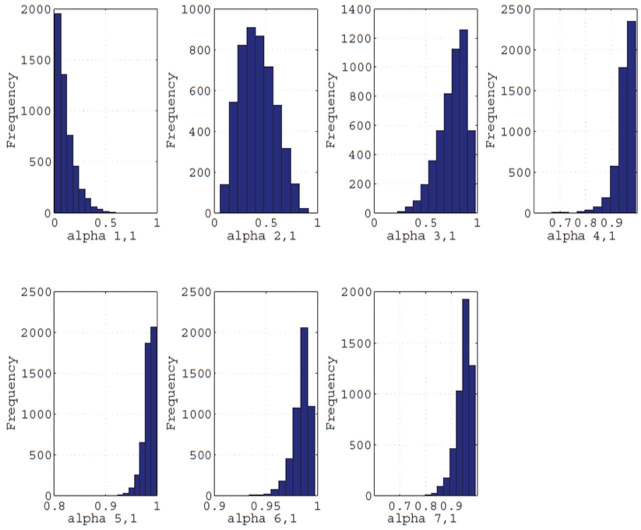

Figure 2: $\alpha_{i,k}$ distributions.

a neat decreasing in the mean values of the β_i distributions when i increases from one to seven (for sake of readability, graphs in Figure 1 are reported with different x-axis scale). This trend has an exception for the 7th DOF, β_7 distribution, which takes greater mean value with respect to β_5 and β_6 distributions. According to what emphasized above, this sensitivity study clearly suggests that to catch the overall behavior it is better to place the pair of a/s at DOF 1. This conclusion is perfectly endorsed by parallel analyses and the common experience.

To capture mode 1, usually the most important, the sensitivity analysis of the $\alpha_{i,1}$ values, summarized in Figure 2, must be considered. Graphs in Figure 2 show a clear increase of the $\alpha_{i,1}$ distributions mean values for increasing i. This informs, considering the physical meaning of our sensitivity parameters, that a better estimation of Mode 1 will be provided by placing the pair of a/s at DOF 7.

The proposed approach address the problem of optimal instrumentation in structural identification. Monte Carlo simulations are required, which will be computationally expensive for complex structures. However, this operation will be done in the experiment design stage, and hence will not hamper fast processing of actual experiment data. Also, this alternative approach is at present in the proof of concept stage, and current research efforts are being directed towards trying different ways (e.g. parallelizing the computations) to improve the computational performance of the approach, as well as investigating analytical and numerical techniques to provide statistical descriptions of the sensitivity coefficients.

4. New General Relations between Complex and Real Eigendata

From a real structural identification using an ERA/OKID approach (as widely discussed in [10]), it is possible to get the complex-valued eigendata of a system. For the practical purpose of structural identification and updating, these parameters must be converted to corresponding real-valued data, and currently there are different approaches in literature (i.e. the methodology reported in [11]). In this paragraph, new general relations capable of transforming complex eigendata into real ones are introduced. These relations hold for a N degrees of freedom systems without assumptions on the mass, stiffness and damping nature. The math behind is omitted and just the conceptual main passages together with the final relations are discussed. Working on the time invariant dynamical model for discrete spatial domain (directly derived from Newton's Second Law), it is usual to enforce an arbitrary eigenvector scaling choice which is formulated throughout

$$\begin{bmatrix} \Psi \\ \Psi\Lambda \end{bmatrix}^T \begin{bmatrix} L & M \\ M & 0 \end{bmatrix} \begin{bmatrix} \Psi \\ \Psi\Lambda \end{bmatrix} = \nu \quad (2)$$

$$\begin{bmatrix} \Psi \\ \Psi\Lambda \end{bmatrix}^T \begin{bmatrix} K & 0 \\ 0 & -M \end{bmatrix} \begin{bmatrix} \Psi \\ \Psi\Lambda \end{bmatrix} = -\nu\Lambda \quad (3)$$

with M, L and K the FE model $R^{N\times N}$ mass, damping and stiffness matrices, $\Lambda_{2N\times 2N}$ the diagonal complex eigenvalue matrix and $\Psi_{N\times 2N}$ the complex eigenvector matrix. The scaling choice is defined through matrix ν which is usually taken equal to the identity: $\nu = I$.

A different approach is here assumed: $\nu = \Lambda - \overline{\Lambda}$ (the upper bar indicates the conjugate operation, see [12] for further details). This alternative scaling choice allows for specific algebraic manipulations of equations (2) and (3), which lead to the formulation of new conversion relations given by

$$\sum_{j=1}^{N} \phi_{ij}^2 = \sum_{j=1}^{N} \left[2\frac{\sigma_j}{\omega_j}\psi_{ij}\varphi_{ij} + \left(\psi_{ij}^2 - \varphi_{ij}^2\right) \right] \quad \forall\, i \in \mathbb{N}_N \quad (4)$$

$$\sum_{j=1}^{N} \phi_{ij}\phi_{kj} = \sum_{j=1}^{N} \left[\frac{\sigma_j}{\omega_j}(\psi_{ij}\varphi_{kj} + \psi_{kj}\varphi_{ij}) + \psi_{ij}\psi_{kj} - \varphi_{ij}\varphi_{kj} \right] \quad \forall\, i \in \mathbb{N}_{N-1}, k \in \{i+1, \dots, N-1\} \quad (5)$$

$$\sum_{j=1}^{N} \frac{\phi_{ij}^2}{\delta_j^2} = \sum_{j=1}^{N} \frac{1}{\sigma_j^2 + \omega_j^2} \left[2\frac{\sigma_j}{\omega_j}\psi_{ij}\varphi_{ij} + \left(\psi_{ij}^2 - \varphi_{ij}^2\right) \right] \quad \forall\, i \in \mathbb{N}_N \quad (6)$$

$$\sum_{j=1}^{N} \frac{\phi_{ij}\phi_{kj}}{\delta_j^2} = \sum_{j=1}^{N} \frac{1}{\sigma_j^2 + \omega_j^2} \left[\frac{\sigma_j}{\omega_j}(\psi_{ij}\varphi_{kj} + \psi_{kj}\varphi_{ij}) - (\psi_{ij}\psi_{kj} - \varphi_{ij}\varphi_{kj}) \right] \quad \forall\, i \in \mathbb{N}_{N-1}, k \in \{i+1, \dots, N-1\} \quad (7)$$

With $\lambda_i=\sigma_i\pm\iota\omega_i$ ($\iota = \sqrt{-1}$) the *i-th* component of the diagonal of the complex eigenvalues matrix $\Lambda_{2N\times 2N}$, $\psi_{i,k}$ and $\varphi_{i,k}$ respectively the real and imaginary part of the *(i,k)-th* component of the complex eigenvector matrix $\Psi_{N\times 2N}$, $\phi_{i,k}$ the component of the real eigenvector matrix and δ_j the j-th real frequency of the system. All the terms on the right hand side of all the equations from (4) to (7) are known after a realization (complex-valued eigendata). The real-valued eigendata of the system, unknowns of the problem, stand all on the left hand side of the mentioned relations. The use of a nonlinear solver, like the Newton-Rapson Method, is sufficient to solve the system of equations. The relations have been tested on real case scenarios producing very positive results (negligible error with respect to the actual real eigendata). A closed form solution for a two DOF system has been also formulated together with further outcomes. For a wide description of the proposed methodology refer to the Master Thesis of the author of this paper [8].

5. Conclusions

A new approach for actuator/sensor location in a structural identification problem with input and output known is presented. For a single set of devices placed in correspondence of one DOF at a time, the optimal location is identified by computing novel sensitivity indices, determined according to the specific identification goal (single mode or the overall behavior).

New general relations to convert complex eigendata coming from ERA/OKID approach into real ones are briefly discussed. A big assumption is limiting these novel converting relations: the system must be fully instrumented. Further developments of the approach to a not fully instrumented scenario are already in progress.

6. Acknowledgments

The work reported herein is a dense and discursive summary of the research activity conducted at Columbia University in the City of New York during the Academic Year 2012 -2013. A particular thanks is due to Professor Betti, Professor of "Theory of Vibration" at the "Dept. of Civil Eng. and Eng. Mechanics" at Columbia University, which has been capable of transmitting the true essence and passion for the research activity; Professor De Angelis, Associate Professor at "Dipartimento di Ingegneria Strutturale e Geotecnica" at Università di Roma "La Sapienza", and Professor Ubertini, Chairman of "Dipartimento di Ingegneria Civile, Chimica, Ambientale e dei Materiali" at Università di Bologna, for their teachings and support. A big acknowledgement is for Suparno Mukhopadhyay, Research Assistant at "Dept. of Civil Eng. and Eng. Mechanics" of Columbia University. His *sleepless* contribution, together with his extraordinary problem-solving capacity, made possible the realization of this work. This paper is dedicated to my family, a thanks is not enough.

7. References

[1] – L. Ljung, T. Glad, "On Global Identifiability for Arbitrary Model Parametrizations", Automatica 30 – 1994, pp. 265-276.

[2] – F. E. Udwadia, D. K. Sharma, "Some Uniqueness Results Related to Building Structural Identification", SIAM Journal on Applied Mathematics 34 – 1978, pp. 104-118.

[3] – G. Franco, R. Betti, R. W. Longman, "On the Uniqueness of Solutions for the Identification of Linear Structural Systems", ASME Journal of Applied Mechanics 73 – 2006, pp. 153–162.

[4] – S. Mukhopadhyay, H. Lus, R. Betti, "Modal Parameter Based Structural Identification Using Iinput-Output Data: Minimal Instrumentation and Global Identifiability Issues", Mechanical Systems and Signal Processing (in print), http://dx.doi.org/10.1016/j.ymssp.2013.11.005.

[5] – F. E. Udwadia, "Methodology for Optimal Sensor Locations for Parameter Identification in Dynamic Systems", ASCE Journal of Engineering Mechanics 120 – 1994, pp. 368–390.

[6] – C. Papadimitriou, "Optimal Sensor Placement Methodology for Parametric Identification of Structural Systems", Journal of Sound and Vibration 278 – 2004, pp. 923–947.

[7] – G. Deodatis, "Lecture Notes on Random Process in Mechanics", Columbia U. – Fall 2010.

[8] – R. Betti, F. Ubertini, S. Mukhopadhyay, B. Argento, "Structural Identification by Means of Induced Vibrations", Master Thesis at Columbia U. and University of Bologna – A.Y. 2012 - 2013.

[9] – R. Betti, F. Ubertini, S. Mukhopadhyay, G. Cardamone, "Vibration Analysis of Structures through Output Only Method: Response Quality Factors", Master Thesis at Columbia University and University of Bologna – A.Y. 2012 - 2013.

[10] – H. Lus, R. Betti, R.W. Longman, "Identification of Linear Structural Systems Using Earthquake Induced Vibration Data", Earthquake Engineering and Structural Dynamics 28 – 1999, pp. 1449–1467.

[11] – H. Lus, M. De Angelis, R. Betti, R.W. Longman, "Constructing Second-Order Models of Mechanical Systems from Identified State Space Realizations. Part I: Theoretical Discussions", ASCE Journal of Engg. Mechanics – 2003.

[12] – E. Balmes, "New Results on the Identification of Normal Modes from Experimental Complex Modes", Mech. Syst. Signal Process – 1997, 11 pp. 229 – 243.

A camera-based control for an AL5D lynx robot

Giancarlo Gramazio

Mechanical and Aerospace Engineering Department
Polytechnic Institute of New York University
6 Metrotech, Brooklyn NY, 11201
gg1296@students.poly.edu

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Android device

Robotic arm

Object detection

Simulink

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Abstract

The objective of this project is to design and implement a vision-based control for an AL5D Lynx robot using a camera attached to the end effector of the robotic arm. By the completion of this effort, the robot has been controlled in two different ways: (1) by applying various inputs to the robot using a computer and (2) by controlling the trajectory of the robot using an Android device (i.e., a mobile phone or a tablet).

The first part of this project involved creating a forward and an inverse kinematics model, focusing on the aforementioned robot, and a control design for the robot using an Arduino microcontroller. Furthermore, a simple mathematical model has been developed to center a camera, attached to the robot, upon a ball and to compute the distance from the camera to the ball. A support structure has been designed to attach the camera to the wrist of the robot without restricting its range of rotation. Moreover, a new gripper has been designed to allow the robot to grasp large objects. A Simulink model has been developed to move the robot, to center the camera upon the object, and to grasp the object. Finally, another Simulink model has been developed to recognize a ball of a certain color, grasp it, and place it into a container of the same color as the ball. This is an autonomous kind of control and it does not require an user to move the robot.

In the second part of this effort, an application for an Android device has been developed to interact with and control the robot. For a comparison, an operation of pick and place has been performed, controlling the robot using a computer and a tablet, showing a clear difference in time between them. The camera-based automatic control has been found to be repeatable and faster than the Android-based manual control.

1. Introduction

In the last few years, vision-based recognition and object localization has attracted research attention in many different areas. Factory automation, based on robots which autonomously interact without any external input or manual intervention, is the most attractive area. Industrial automation has several goals. The most important goal is to replace the human workforce in places where accuracy, sensitivity, and reliability are paramount. In many aspects, robots can already outperform human workers. Vendors of industrial robots have developed several solutions to enable robots to operate in a specific environment. However, these solutions are usually expensive and specifically tailored to one type of operational environment[1].

In this effort, we propose a simple, low-cost solution to the above problem. Our proposed solution is a compromise among the cost, accuracy, and speed. Of course, we may be able to further enhance the system's accuracy with increased cost. To demonstrate our proof-of-concept, we use the AL5D Lynx robot. This robot has four degrees of freedom due to the presence of four joints each of which is controlled using a servo motor. That is, one servo motor attached to the base simulates the waist of a human, one servo motor simulates the shoulder of a human arm, one servo motor simulates the elbow, and the last servo motor simulates the wrist[3]. Although a human arm has seven degrees of freedom and the Lynx robot has only four, the movement of this robotic arm is very close to a human arm and it can reach a large number of target configurations.

To clearly understand how a robot moves, it is needed to clarify the difference between the forward and the inverse kinematics and explain how to send data from a computer to a robot.

There are two different ways to move a robot: (1) by giving input commands to individual servo motors to command corresponding joints and (2) by controlling the position of the end effector of the robotic arm. The first method is called forward kinematics, while the second method is called inverse kinematics. In our work, the values of the commanded angles are sent using serial communication from the Simulink program, running on the computer, to an Arduino microcontroller, which serves as an embedded controller for the robot.

2. Materials and Methods

To design a camera-based control system for a robot, following components are required.

- An AL5D Lynx robot or any other kind of 4-R robot;
- An Arduino microcontroller
- A servo controller
- A quality camera
- A computer with the Matlab-Simulink software

The AL5D Lynx robot is made of aluminum and it delivers fast, accurate, and repeatable movement. It can also be controlled directly from an easy to program microcontroller such as an Arduino.
Use of the Arduino library makes it possible to send the data from Simulink to the Arduino microcontroller. Because the Arduino library only allows the microcontroller to receive integers, the commands are converted from float numbers to integers before they are sent to the Arduino microcontroller. Using this approach the experimental results were found to be not very precise. In fact, each joint has a ±0.5° uncertainty which results in a position for the end effector that is different from the desired one. Thus, the servo controller presents an alternative solution to reduce the error of the position of the end effector and to make the movement of the robotic arm smoother. An Arduino program is required to receive data from Simulink and to pass it to the servo controller.
To enhance gripper positioning for object capture, it is important to attach the camera to the robot so that there is no relative motion between the camera and the robot. The camera has to be almost parallel to the base of the robot to simplify the calculations that provide the coordinates of the centroid of the object. A broad field of view is required so that the object to be grasped by the robot can stay at a safe distance from the robotic arm. Unfortunately, in this project, the camera has a small field of view and so the object has to be almost on the manipulator trajectory to be seen.
The following four steps have been necessary to grab a ball using the robotic arm.

- Development of an inverse kinematics model applying the Denavit-Hartenberg notation
- Design of mechanical appendages for the robot
- Development of a mathematical model to center the ball inside the plane of the camera and to determine the distance from the camera to the centroid of the ball
- Development of a Simulink model to detect the ball and to move the robot to grab it

For inverse kinematics, two different approaches can be used to develop an appropriate model (1) either calculating the relations between the final position of the gripper and the angles between the links of the robot or (2) empirically associate to many positions of the gripper a set of values for the angles in each joint to get that position. Interpolating is possible to get the values for intermediate positions.
In this effort, the first method has been used. It is a general technique and it can be used for all robots with four revolute joints by changing the dimensions of the arm and of the forearm within the Matlab code.
To get the equations that relate the position of the gripper to the angles between the joints, a forward kinematics model has been developed by applying the Denavit-Hartenberg representation[2] (Figure1).

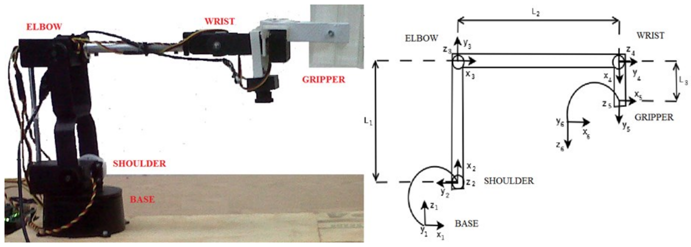

Figure 1: Schematic representation of the robot.

All the transformation matrices have been calculated to pass from one frame attached to a joint to another. In particular, from the matrix that relates the tool frame to the base frame of the robot, it is possible to get the relation between the angles in the joints and the position of the end effector. Inverting these equations, all the values for the angles can be calculated easily with a low computational time. For a single position of the end effector two different solutions are given from these equations. Fixing an appropriate interval (i.e., from 0° to 180°), the solution of the problem becomes unique.
Some mechanical tools were designed to allow the robot to better perform its tasks. Since the standard gripper that comes with the Lynx robot is too small to grab a 5-cm diameter ball, a new gripper (Figure 2) was designed to grab bigger objects.
The new gripper has the same operation's principle of the standard one, transforming the rotary motion of a servo into a linear motion of the cups of the gripper. Furthermore, a support for the camera (Figure 3) was designed to attach the

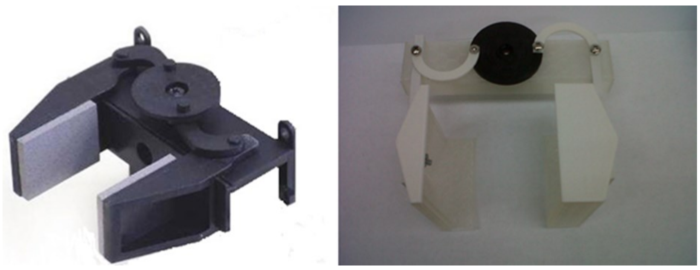
Figure 2: Standard and new gripper for the Lynx AL5D robot.

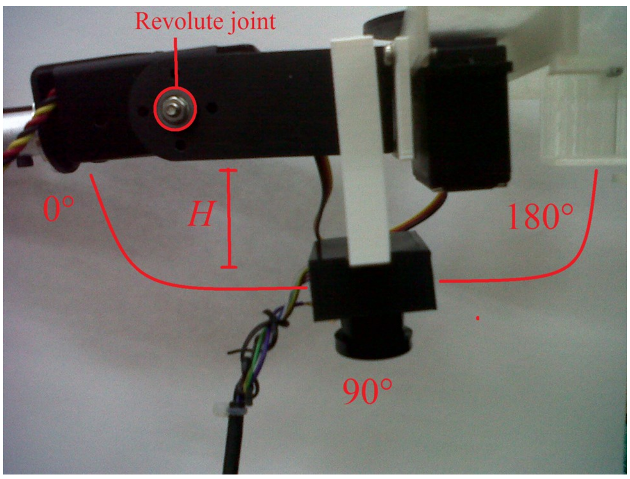

Figure 3: Possible motions of the wrist.

camera to the wrist of the robot avoiding contact with the forearm of the robot.
Object detection is, by definition, a computational technique related to computer vision and image processing that deals with detecting instances of semantic objects of a certain class (such as humans, buildings, or cars) in digital images and videos[4].
The most important ways to detect an object include

- stationary-moving object detection[5]
- color-based object detection
- shape-based object detection

The first approach can recognize objects by measuring the velocity of an object inside the frames (Figure 4).

Figure 4: Example of object detection.

In this effort, such an algorithm has been used to detect the position of the ball.
A mathematical model to center the object and to compute the distance between the camera and the centroid of the ball has been developed. To center the ball, a bang-bang control approach is performed. A bang-bang controller is a feedback controller that switches abruptly between two states. When the robot sees the ball, it starts moving until the components of the distance between the centroid of the ball and the center of the camera are within a certain range (the precision error desired by the user). Then, the robot stops moving and the camera is exactly upon the ball. As long as the ball is inside that range, the robot does not move. Since the ball is not moving, the bang-bang control is an appropriate solution.
The distance between the camera and the ball must be calculated before grabbing the ball. There are two possibilities to compute this distance: (1) estimating the dimension of the ball (for instance, using two cameras[6]) and (2) knowing it *a priori*. It is possible to estimate the dimension of the ball by comparing the diameter in pixels of two different positions. This approach has too many uncertainties and the distance calculated is not close enough to the real value. The second approach has a big restriction (the diameter is assumed to be known) but it is quite precise and reliable. Knowing the diameter, we can compute the scale factor (mm/pixel) which is valid for the plane passing through the center of the ball and parallel to the plane of the camera. Applying some trigonometric properties (Figure 5, where L=240 pixels, x is the field of view of the camera and it is 24°, and H is the unknown distance), the distance between the camera and ball can be easily computed by using the scale factor. This model is completely general and works well for every position of the ball.
By the end of this effort, a Simulink model has been developed to control the robot. All the velocities of the robot are assumed to be constant and they can be defined by the user in the Simulink model.

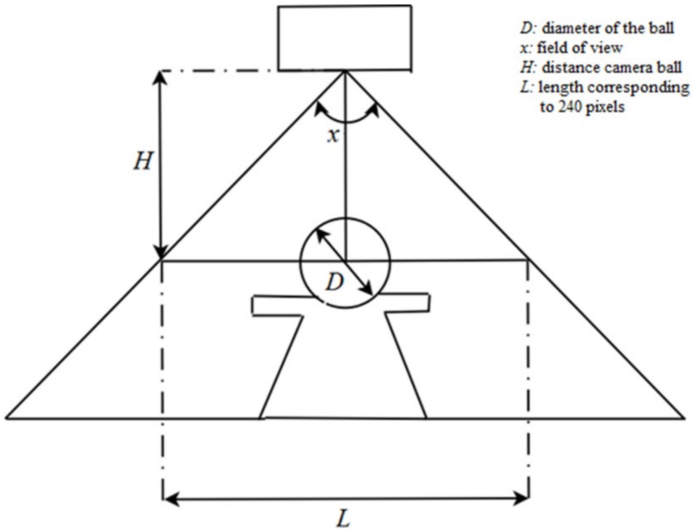

Figure 5: Schematic representation of the plane camera ball to compute the distance between the camera and the centroid of the ball.

3. Results and Analysis

Two different Simulink models have been developed: one to grab the ball and one to detect a ball of a certain color and place it in a bin of the same color as the ball. The first Simulink model can be used to grab an object (Figure 6) that is inside the workspace of the robot and inside the field of view of the camera.
The time required to complete this task depends on the constant velocity of the robot set by the user. Since the field of view of the camera used is small, the ball has to be almost on the trajectory of the robot to be seen by the camera. A second Simulink model has been developed to detect colors in imag-

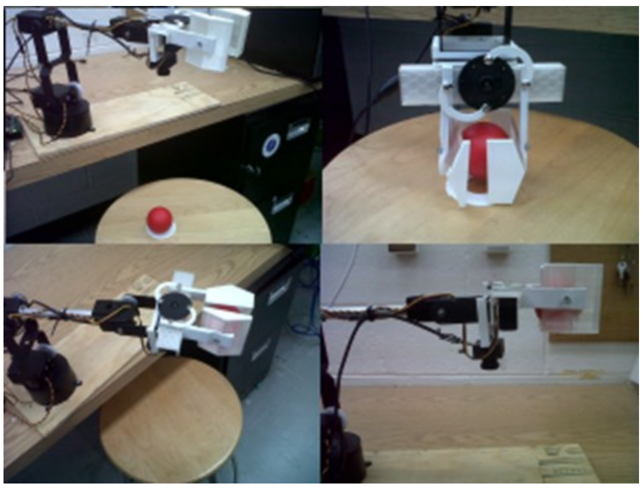

Figure 6: Grabbing a ball using an AL5D Lynx robot.

es captured by a camera. This allows the robot to recognize balls of different colors and place them in the corresponding bins (Figure 7). Brightness has a detrimental role in this kind of object detection. In fact, if there is too much light (or too

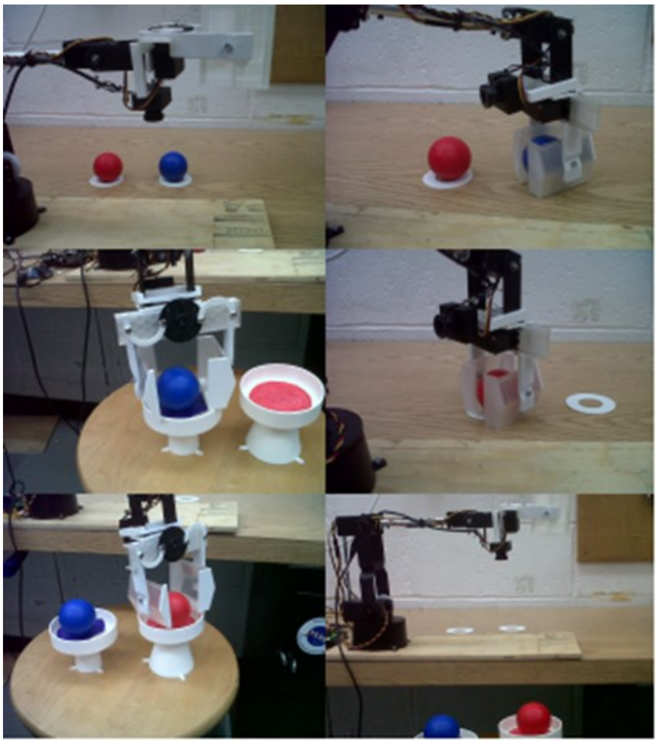

Figure 7: Operation of pick and place.

little light), the camera will recognize just a small part of the ball. In this way, the diameter in pixels is smaller than its real value and this has an influence on the calculation of the distance between the camera and the ball (the scale factor is different).
By the end of this effort, a Simulink model has been developed to control the Lynx robot with an Android device. The time required to pick up a ball using this kind of control is almost twice the time required using the automatic control, assuming same velocities for each movement. Hence, for operation of pick and place, the automatic control of the robot is much better than controlling the robot using an Android device. Table I and Table II show the time required to grasp the ball by controlling the robot using an Android device and by applying the vision-based automatic control.
The ball has been put in two different positions.
The time to grasp the ball by using the aforementioned algorithm is much less than the time to grasp the ball by using an Android device for several reasons.

Trials	Time to grasp the ball (position 1)	Time to grasp the ball (position 2)
Student 1	2’ 04”	1’ 11”
Student 2	2’ 17”	1’ 55”
Student 3	2’ 20”	2’ 55”
Student 4	1’ 35”	50”

Table I: Time to grasp the ball by controlling the robot with an Android device.

Trials	Time to grasp the ball (position 1)	Time to grasp the ball (position 2)
1	45”	30”
2	47”	35”
3	43”	35”
4	44”	33”

Table II: Time to grasp the ball by using the camera-based automatic control.

First of all, since the algorithm is completely automatic, there are no idle times. On the contrary, the user who controls the robot by using an Android device has to think before moving the manipulator and s/he has to push the buttons to move it.
Secondly, the user shows a lot of difficulties in centering the end effector upon the ball. The user has to change the direction of the movement several times before reaching the centroid of the ball, wasting time. On the contrary, the algorithm moves the robot so that the camera centers the ball with one movement. This operation saves a big amount of time.
Finally, the algorithm moves the robot on a circular trajectory to find the ball. The circular trajectory is a good compromise between increasing the probability to find the ball and reducing the space to reach the ball. Conversely, the user can move the robot only on linear trajectories parallel to the vectors of the manipulator basic frame, increasing the space and the time required to reach the ball.
It would be interesting to repeat the experiment considering more variables like the user experience to move the robot by using an Android device, considering more positions for the ball, and also to repeat the experiment for operation of pick and place.
As future work, it would be interesting to send the video from Simulink to the Android device so that the user can control the robot and grasp the ball, staying far from them. In this way, the user can move the robot until s/he sees the ball. Then, by a press of a button on the Android device, the control can be passed to the automatic algorithm to grasp the ball. In this way, the time to grasp the ball is still low (the user does not have to center the ball) and the ball does not have to be on the trajectory of the robot. Furthermore, since the user sees the object on the Android device, s/he can be far from it and the work of a human being can be replaced by the work of a manipulator.

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5. References

[1] Patrick A. Seidel and Kay Bohnke. Camera-based control for industrial robots using opencv libraries. *Communications in Computer and Information Science*, 82, pp.144-157, 2010.
[2] John J. Craig. *Introduction to Robotics, Mechanics and Control*, Third Edition, Pearson, 2008.
[3] Mahmoud Tarokh, Kancherla Keerthi, and Malrey Lee. Classification and characterization of inverse kinematics solutions for anthropomorphic manipulators. *Robotics and Autonomous Systems*, 58, pp. 115-120, 2010.
[4] Zhiqiang Wei, Xiaopeng Ji, and Peng Wang. Real-time moving object detection for video monitoring systems. *Intelligent Information Technology Application*, 8, pp.163-166, 2008.
[5] Nikolas P. Papanikolopoulos, Pradeep K. Khosla, and Takeo Kanade. Visual tracking of a moving target by a camera mounted on a robot: a combination of control and vision. *Robotics and Automation*, 9, pp. 14-35, 1993.
[6] Emilio J. Gonzalez-Galvan, Sergio R. Cruz-Ramirez, Michael J. Seelinger, and J. Jesus Cervantes-Sanchez. An efficient multi-camera, multi-target scheme for the three-dimensional control of robots using uncalibrated vision. *Robotics and Computer-Integrated Manufacturing*, 19, pp. 387-400, 2003.

Inter-building effect: on the impact of surrounding boundary conditions on the accuracy of building energy performance predictions

Anna Laura Pisello, PhD

CIRIAF – University of Perugia
Department of Engineering
Via Duranti 67, 06125, Perugia, Italy
pisello@crbnet.it

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Building networks
Dynamic Simulation
Neighborhood
Peer network effect
Urban Heat Island

Abstract

This series of works and research contributions has been elaborated by a group of researchers led by professor John Eric Taylor which was the director of the Dynamics Lab at Columbia University up to December 2012, when the author was visiting scholar at Columbia University, thanks to the support of H2CU. The research cooperation among the authors is still alive and the research group now consists of several members from different academic institutions in the US and in Italy. In particular, these members are, together with the author of this contribution, Professor John E. Taylor (Virginia Tech, VA), Professor Franco Cotana (University of Perugia, Italy), Professor Francesco Asdrubali (University of Perugia, Italy), Professor Patricia Culligan (Columbia University, NY), Dr. Xiaouqi Xu (Harvard University, MA), Ryan Qi Wang (Virginia Tech, VA), Veronica Castaldo (University of Perugia, Italy). The present work is a synopsis of the recent papers published by the author, where particular attention is paid to the physical aspect of the Inter-Building Effect (IBE), which is the main contribution of the author in the group during 2011 and 2012. Further development of the research and on-going works are finally introduced.

1. Introduction

Modeling the energy behavior of buildings has become a crucial issue for both building designers and researchers, considering the large amount of energy consumed by the built environment and the concomitant potential for energy saving. Previous research [1] has indicated that 36% of total global energy consumption is attributable to buildings. A United Nations' study [2] has also indicated that by 2050, a significant shift in population from rural areas to urban areas will occur. Population in urban areas is predicted to increase by about 40%, and over the same period, population in rural areas will decrease by about the same percentage. Coupled with this migration to urban areas, it would be reasonable to expect the morphology of urban areas to involve tighter spatial interrelationships among buildings. This trend is already evident in the dense urban and quasi-urban areas of the world's largest cities. Our understanding of buildings needs to evolve to accommodate people and buildings into closer proximity. It may be current modeling approaches that treat buildings as stand-alone entities do not accurately represent a building's energy performance because they often do not consider: (i) the close proximity of other buildings in a urban environment, (ii) the local specific climate conditions such as urban heat island phenomenon or microclimate peculiarities, e.g. the presence of vegetation, urban canyons, etc., (iii) the relationship between occupants' communities and the role of their awareness about the energy issue, and the energy implications that these three aspects could cause. The purpose of this research is to propose a systematic method for assessing these combined effect across buildings and to examine the potential magnitude of such an overall multipurpose effect. This combined effect will be referred to as the Inter-Building Effect (IBE). If it can be demonstrated that such an Inter-Building Effect can exist among buildings, it would become crucially important to develop a more robust understanding of how networks of buildings interact in terms of energy dynamics in order to accurately predict building energy use.

The research presented in this synopsis builds upon previous approaches concerning the study of energy and thermal performance [3] of stand-alone buildings afforded by dynamic simulation. As an extension to this research, the investigation enlarges the problem perspective in order to analyze more realistic boundary conditions given the evolving context of urbanization. More specifically, this work quantifies the change in energy consumption that may derive from assessing a building situated in its real network of buildings context, by taking into account: buildings located in close proximity and in different climate (section 2), the relationship between occupants' clusters (section 3), the role of meso-climate phenomena such as urban heat island (section 4).

2. The IBE impact on indoor thermal behavior and energy consumption

2.1 A typical suburban block in the US

The proposed methodology is applied for assessing the IBE within an American urban neighborhood block as shown in Figure 1 [4-5]. After examining the urban and suburban morphologies of many of the largest cities in the United States, a representative block located in Albany, New York (42°39' N; 73°45' W) was chosen to study the IBE. This block contains a group of twenty single-family residential buildings positioned on two sides and separated by a typical neighborhood street with two sidewalks. All the buildings are described within the dynamic simulation environment with consideration for realistic dwelling indoor thermal zones, occupants' schedules, and envelope materials. The indoor thermal environment of the control building was analyzed in both the single-building scenario (S-BS) and in the network-of-buildings scenario (N-BS) assuming the block was located in Minneapolis, Minnesota (MN) and in Miami, Florida (FL). Figures 2 and 3 show the hourly trends of four days of the year: January 21st for winter, April 21st for spring, July 21st for summer, and October 21st for fall. These graphs plot the thermal profiles of operative indoor temperature, to describe the indoor thermal conditions of the living-room control building. The Primary Energy requirements refers to the target temperatures, 26°C (maximum for summer) and 20°C (minimum for winter), considering residential building, occupants' sedentary activity and intermediate acceptance category. Also the thermal balance through the building's envelope is assessed, considering both internal gains through windows S and opaque walls G. An important variation was found for all the parameters that could lead to the IBE phenomenon. The indoor temperature registers high average difference throughout the year, between 3°C in summer and 6.5°C in winter in Minneapolis (Fig. 2), and up to 10°C in winter in Miami (Fig. 3). The same occurs for solar gains

Figure 1: Layout of the network of buildings.

through windows, which are dampened by the physical presence of other buildings within the network morphology (Fig.1). Additionally, the thermal exchange through opaque walls is reduced, particularly in cold weather conditions because the thermal losses through convection and radiation are reduced by the presence of nearby buildings. When the IBE inhibits the solar radiation from entering into the building, a higher level of energy may be required for heating. However, the IBE may also reduce energy consumption during cold weather periods due to a reduction of thermal exchanges through the envelope both for convection and radiation. The two graphs on the right in Figure 2 illustrate that trend during winter days. The graph in Figure 4 shows the monthly trend of IBE in terms of percentage of energy requirement underestimation (top half of the graph) and over-estimation (bottom half of the graph) for both cooling and heating. This graph illustrates the magnitude of energy estimation inaccuracies when the control building analysis (S-BS) is expanded to include its surrounding buildings (N-BS) in the two climatological contexts. Substantial energy over-estimation amounts are found, meaning that less energy is needed than predicted due to the IBE. This is largely due to mutual shading across the network of buildings. Those over-estimation amounts were up to 58% for Miami and up to 37% for Minneapolis. At the same time, energy under-estimation of up to 32% was observed for the residential block modeled during cooler weather months in Minneapolis.

2.2. The historic city center of an Italian ancient city

The proposed methodology is then applied to analyze the IBE extent in residential multi-family buildings located in a typical ancient city in central Italy, Perugia. The thermal-energy performance of three buildings located in different urban density areas are modeled and simulated within a dynamic simulation environment. As previously dealt with, their behavior was simulated in stand-alone configuration and in urban context to examine the impact of close spatial relationships among buildings in neighborhoods of varying density. Results confirm previous findings that buildings mutually impact the thermal performance of close buildings, and further demonstrate that this impact is correlated to urban density. Figure 5 reports the aerial views of the three considered areas in Perugia, Italy. The choice of the three case study buildings was determined by the h/d ratio (building height / mutual distance). In fact, the three areas present constant mutual ratio between h/d values of 2.5. The indoor thermal behavior of the three case study buildings was analyzed in both stand-alone and inter-building configuration. Figure 6 represents the hourly operative indoor trend during summer and winter conditions of three days in July and January, respectively. Large differences between the two considered scenarios were found, demonstrating the important IBE and the urban characterization roles in determining the realistic indoor thermal profile and therefore, thermal comfort conditions. In the non-dense area, on the contrary, the same results report a negligible average IBE in both winter and summer. In the very dense urban area, the maximum difference is registered in July, and it corresponds to 3.5°C, while the average difference of the analyzed days is 2.0°C. In both the cases, the building modeled within its surrounding is colder than the same building simulated as stand-alone, given the mutual shading effect of close buildings.

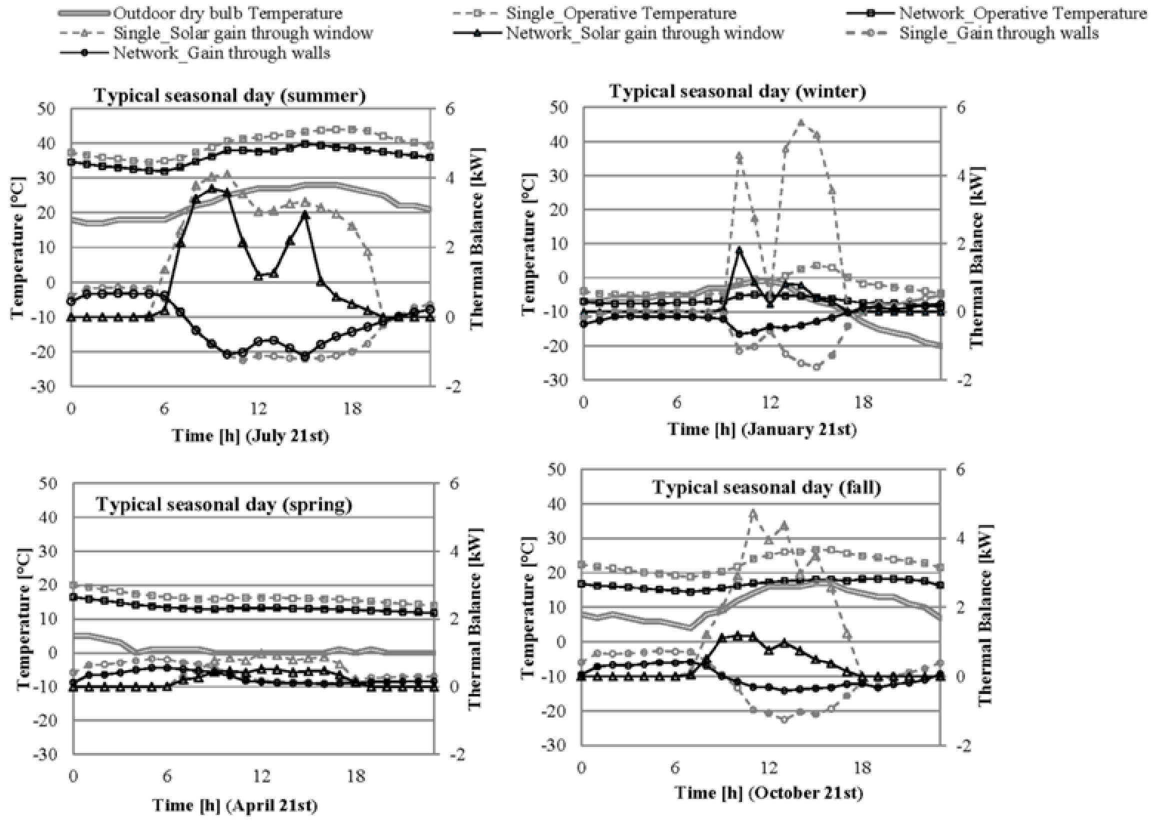

Figure 2: Indoor thermal analysis. Comparison between S-BS and N-BS in Minneapolis, Minnesota.

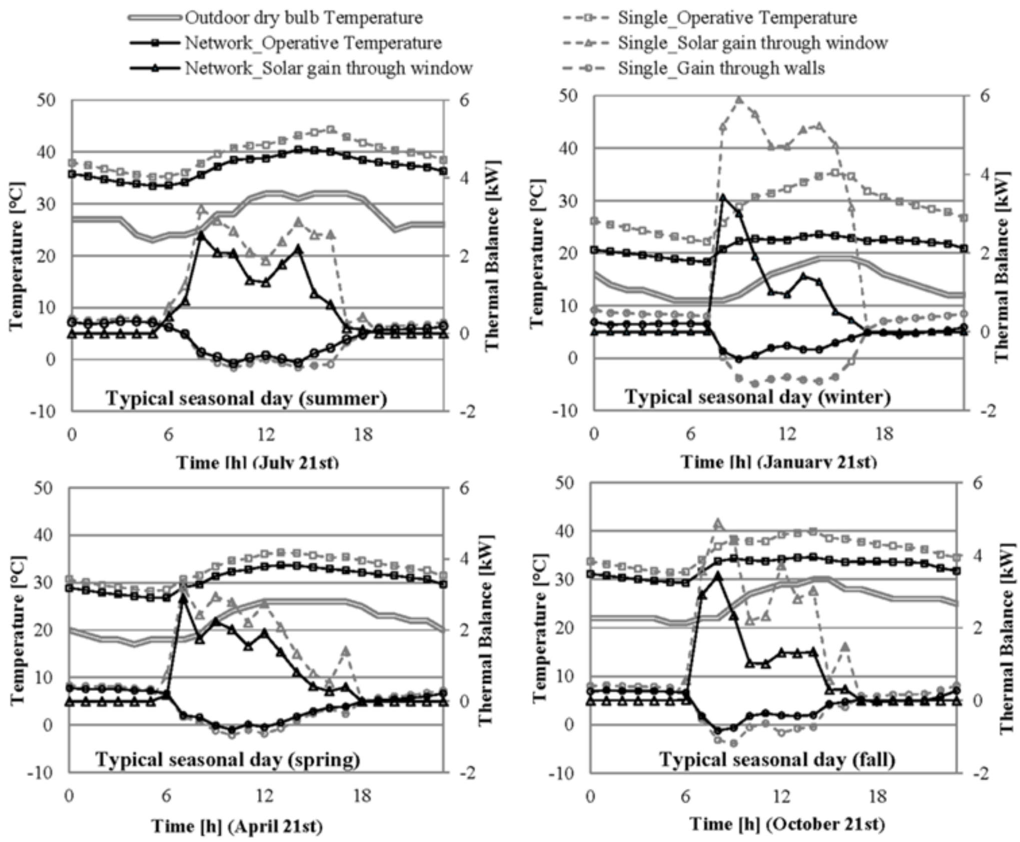

Figure 3: Indoor thermal analysis. Comparison between S-BS and N-BS in Miami, Florida.

The same IBE in winter is much lower, given (i) the lower impact of mutual shading, (ii) the lower solar radiation intensity in that period.

3. The impact of place-based affiliation networks on energy conservation

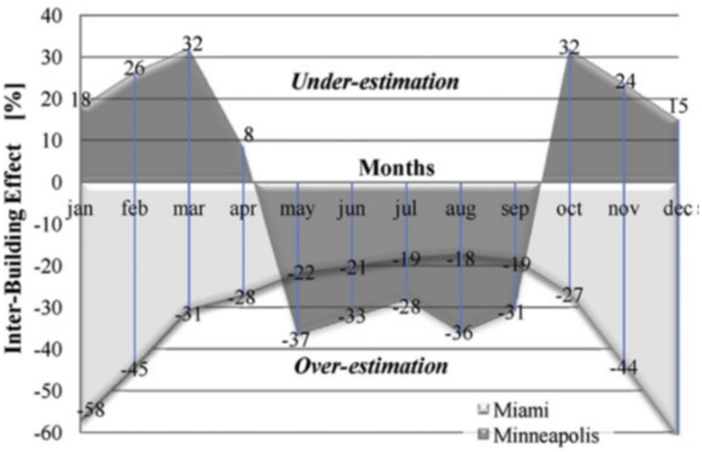

Figure 4: Year-round profile of Inter-Building Effect [%] for Minneapolis and Miami

This study answers the question of how leveraging place-based social network could affect energy conservation performance at the inter-building level above and beyond efficiencies gained through typical building retrofit.

Models that consider, separately, the energy use of networks of buildings and networks of building occupants have been explored in existing literature toward the goal of understanding the role of building networks or occupant networks on building energy conservation. Yet, the neighborhood surrounding buildings and their occupants can also have an influence on energy consumption patterns. Thus, the inclusion of this influence is important in an holistic evaluation of the built environment for aggregate energy performance. As development of the IBE analysis, here an integrated, inter-building model comprised of a building network, an occupant social network, and the surrounding neighborhood facilities, is elaborated to conduct a three-stage prediction of energy conservation potential for an assumed urban residential block. The utilization of neighborhood facilities is carried out from U.S. Census demographic data and therefore, the affiliation network theory is applied to deduce inter-building occupant affiliation networks, and thus predict the potential spread of energy conservation that might be achieved via a combination of social networks and eco-feedback systems for our assumed block. The results of the proposed model show that eco-feedback systems that leverage place-based social networks might lead to improvements in energy efficiency performance at the inter-building level that are comparable to efficiencies gained through typical building retrofits such as windows' and walls' insulation improvement, or thermal plants' substitution. To achieve the research goals, we integrated models for building and human networks to examine energy consumption dynamics in a hypothetical neighborhood block whose building occupants' social networks are formed at a neighborhood level. Our methodology flow can be conceptually divided into an individual building level and an inter-building level analyses, respectively, as well as three stages operationally incorporating two models. The proposed methodology is applied for assessing the IBE within an American urban neighborhood. Figure 7 displays the detailed energy consumption for each of the six patterns of place frequenting and their weighted average during a typical summer month.

Figure 5: Aerial view of the (i) very dense urban area, (ii) dense urban area, and (iii) non-dense urban area.

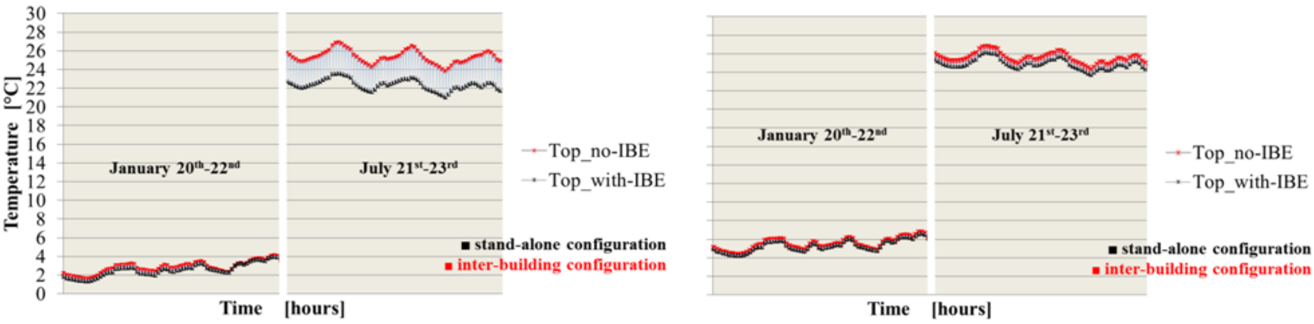

Figure 6: Operative indoor temperature during 3 days (3 curves) in January and July of the building in very dense (i) and in dense context (ii).

This research is aimed at demonstrating the potential energy conservation that might be achieved by capitalizing on the strength of social ties and networks within a neighborhood as determined by neighborhood affiliations.

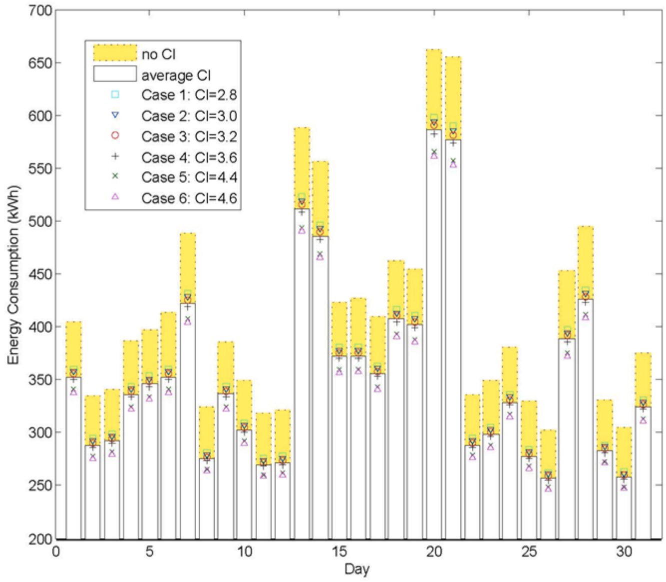

Figure 7: Reduced energy consumption under derived human network (average and deviations) [7]

Though the usage is largely influenced by weather conditions as simulation inputs, the relative reduction because of closer networks is revealed by the highlighted area on the top of each bar. The deviation of different cases is small, with all data points closely gathered around their average. The sequence of cases follows the legend from top to bottom. The centralized result indicates that, as long as the attendance/visitation rate at a neighborhood site is predefined from demographics, the various realization of place-based affiliation network design will not bring unacceptable noise. With the precision of our approach justified, the block energy saving of approximately 11.7% is expected to reflect the role of neighborhood context in a world where such closeness is harnessed to invoke energy efficient behaviors. This savings is at approximately the same level as the physical retrofit scenarios (cases 1 to 6 in Figure 7) which resulted in 2.3–22.3% less energy being consumed [7-8].

4. The role of IBE and meso-climate realistic boundary conditions

In this recent development of the work, the evaluation of the IBE is coupled with the error commonly carried out while the thermal-energy assessment of buildings is operated without taking into account real climate conditions of urban areas. In fact, in large and dense cities in particular, weather conditions could be significantly different with respect to the typical meteorological year, which is the weather reference commonly used while performing dynamic simulation. In this view, different urban densities are chosen in Manhattan, NY, characterized by huge urban heat island phenomenon. An office building and a residential building are modeled and simulated. The IBE is estimated in these three real contexts in Manhattan. Finally, the cumulative error is evaluated by considering real heat island climate data, properly manipulated to represent a year-round weather boundary condition in the dynamic simulation models of the buildings.

Figure 8 reports the two real buildings and their models' layout when located in three different contexts. Figure 9 reports the result of the year-round IBE for the two buildings, in the three considered urban areas: Soho (low density), Hell's kitchen (high density), and Theatre district (very high density).

Figure 10 reports the primary energy requirement for the office building in Hell's kitchen, where it is effectively located. The green line represent the estimated energy requirement calculated by considering the IBE and by neglecting real climate conditions. The blue line represents the detailed model, where both the phenomena are taken into account. The red line concerns the typical dynamic simulation praxis, which usually neglects both IBE and local climate conditions.

5. Discussion and conclusions

In this synopsis, a method for evaluating the energy performance of buildings from an inter-building perspective was

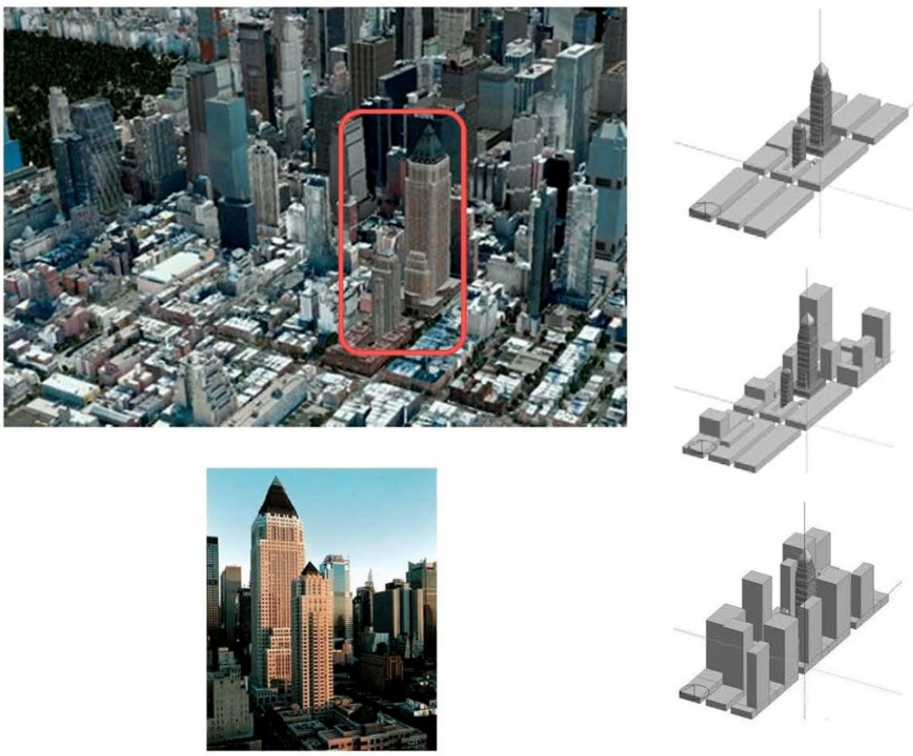

Figure 8: Choice of the two case study buildings and layout of the models

proposed and described. This method was also applied to: (i) a real American urban block morphology of twenty single-

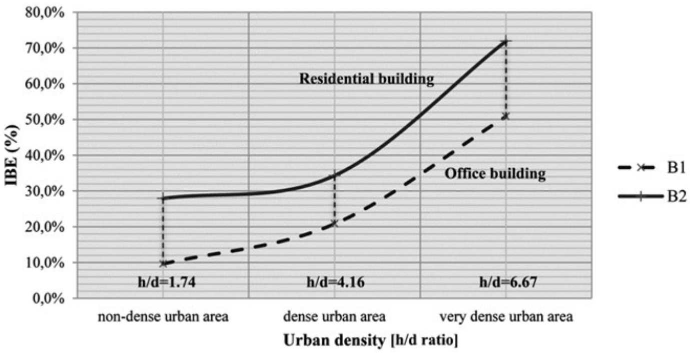

Figure 9 IBE trend with varying urban density for the two case study buildings

family residential buildings, (ii) an Italian historic city center, (iii) a dense modern urban areas in Manhattan, NY. Both technical and architectural characteristics of the blocks are considered and the inter-building occupants' relationships are also evaluated.

The overall research was aimed at examining the potential for an Inter-Building Effect that may impact energy use modeling predictions when the level of analysis is expanded from single building to the network of buildings that surrounds a modeled building, by taking into account both urban configuration and urban occupants' relationships. First findings

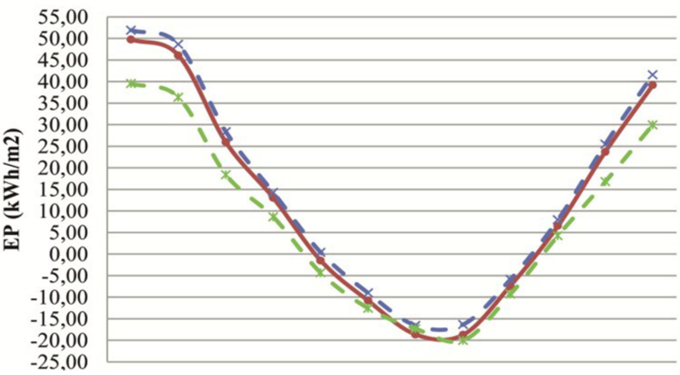

Figure 10 Primary Energy requirement of the office building calculated by neglecting IBE and local climate (red line), by considering just the IBE (green line), by considering both the phenomena (blue line) [9].

demonstrated that the indoor thermal environment of the control-building exhibited large thermal differences (more than 30% depending on urban context and climate conditions) in seasonal average indoor operative temperature when modeled within a network of buildings. The differences in fall and winter were up to 9°C in Minneapolis and up to 13° C in Miami. Temperature difference was up to 4°C in central Italy during summer weather conditions for the dense historic city center. Finally, the calculation of the IBE for the urban block of homes was studied in terms of inaccuracies in energy need prediction for heating and cooling by simulation. Large inaccuracies were found to have been created by the IBE for all the climatological conditions considered in this work. The IBE resulted in an under-estimation inaccuracy of the energy requirement of up to 32% during cold weather months in Minneapolis and an over-estimation inaccuracy of up to 58% during warm weather months in Miami.

Looking at these important results both in terms of primary energy and indoor operative temperature inaccuracies, the first part of the research has demonstrated that buildings can meaningfully impact the energy performance of other buildings when they are in close proximity as is the case in urban and quasi-urban environments. This impact could have an even larger effect if building energy requirement is considered as an urban issue, given that the overall neighborhood energy need could be largely affected by inter-building phenomena impacting urban policies and optimization strategies.

The second study answered the question of how leveraging place-based social network could affect energy conservation performance at the inter-building level above and beyond efficiencies gained through typical building retrofit, evaluated through IBE methodology. It drew from earlier research about the physical IBE modeling and analysis about physical building network. A place-based social network was built using an affiliation network approach, and artificial neural network methods were applied to examine the impact of integrating buildings as physical and social networks that influence energy consumption situated in neighborhood context. The main results showed that, compared to the baseline case where residents do not influence each other's energy consumption, the residential block has a potential for consuming 2.3–22.3% less energy when renovated with typical energy efficient physical design, and an additional potential for saving 11.7–31.1% energy if interpersonal closeness is leveraged for encouraging energy conservation behavior. Theoretically, a holistic model is established to evaluate built environment energy efficiency performance that consists of three components: building networks, occupant social networks, and the surrounding neighborhood facilities.

The third part of this work also concerned the IBE assessment in modern varying urban density. The influence of real urban climate conditions is then included, spanning the boundary of the urban block, in order to consider meso-scale climate phenomena. Main results showed that the IBE extent has the same order of magnitude of the error carried out by neglecting specific urban climate phenomena, such as Urban Heat Island in New York City.

The overall research contribution about Inter-Building Effects showed that such an effect should be taken into account in order to evaluate building energy performance and to design effective energy retrofit solutions for buildings whose thermal-energy behavior is radically impacted by such effect. This is crucial as there is a trend in population migration into urban areas which will bring both people and buildings into closer proximity raising the importance level of understanding the IBE for building design and retrofit decisions, as well as urban planning considerations. Moving forward, it will become increasingly important to consider buildings' impact and urban climate phenomena on the energy use of other buildings in order to capture the significant Inter-Building Effect which can impact the accuracy of building energy simulation predictions, particularly in dense urbanized areas all over the word.

6. On-going research and future developments

Several developments of the research are still in progress and the following future improvements of the methodology will be carried out in the IBE investigation. In particular, the eval-

uation of the IBE in terms of primary energy for cooling, heating and lighting through calibrated dynamic simulation of a university campus in Italy will be investigated. Additionally, the experimental validation of an agent-based simulation model coupled with a physical model applied to a village of residential buildings in Italy is ongoing. Occupants' clusters are designed and continuous monitoring of energy consumption (water use, electricity and natural gas) is carried out in order to evaluate the effect of (i) energy saving awareness, and of (ii) mutual relationships, on the possibility to save further energy.
A future activity consists of the elaboration of a new urban GIS layer where IBE extent is mapped and the primary energy estimation error represents a sort of parameter related to urban development in the city of Manhattan, NY.
For what concerns meso-climate phenomena to be integrated into the IBE theory, the analysis of Italian Urban Heat Island phenomenon in Milan through the evaluation of several years of collected weather data in different urban and suburban weather stations will be studied, for quantifying the difference in energy predictions produced by peculiar urban climate phenomena.
From a building efficiency optimization perspective, the analysis of specific materials for building façade aimed at improving building energy efficiency and urban environment quality at IBE level is investigated. Their features are able to optimize building thermal behavior without impacting surrounding buildings located in close proximity. The study concerns retro-reflective layers for building façade. Analytical model is proposed [10] together with an experimental bench for evaluating their optical features. A full-scale physical model is going to be operative at University of Perugia, Italy [11].

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References

[1] U.S. Green Building Council; 2011. http://www.usgbc.org/Default.aspx [Last accessed 2.12.11].
[2] United Nations. World urbanization prospects: the 2007 revision population database, anel 1: urban and rural areas. http://esa.un.org/unup/; 2011 [Last accessed 10.04.11].
[3] Pisello AL, Goretti M, Cotana F. A method for assessing buildings' energy efficiency by dynamic simulation and experimental activity. Appl Energy, http://dx.doi.org/10.1016/j.apenergy.2011.12.094; 2012.
[4] Pisello AL, Taylor JE, Xu X, Cotana F. Inter-building effect: Simulating the impact of a network of buildings on the accuracy of building energy performance predictions. Building and Environment. http://dx.doi.org/10.1016/j.buildenv.2012.06.017.
[5] Pisello AL, Xu X, Taylor JE, Cotana F. Network of buildings' impact on indoor thermal performance. Smart and Sustainable Built Environment. http://dx.doi.org/10.1108/20466091211227061
[6] Pisello AL, Taylor JE, Cotana F. Simulating the effect of urban morphology on indoor thermal behavior: an Italian case study. Proceedings of the 2013 Winter Simulation Conference R. Pasupathy, S.-H. Kim, A. Tolk, R. Hill, and M. E. Kuhl, eds. December 2013.
[7] Xu X, Taylor JE, Pisello AL, Culligan P. The impact of place-based affiliation networks on energy conservation: An holistic model that integrates the influence of buildings, residents and the neighborhood context. Energy and Buildings. http://dx.doi.org/10.1016/j.enbuild.2012.09.013.
[8] Xu X, Taylor JE, Pisello AL. Network Synergy Effect: Establishing a Synergy between Building Network and Peer Network Energy Conservation Efforts. http://dx.doi.org/10.1016/j.enbuild.2013.09.017.
[9] Pisello AL, Castaldo VL, Poli T, Cotana F. Simulating buildings' thermal-energy performance at urban scale: evaluation of Inter-Building Effect in different urban configurations. *Under review.*
[10] Rossi F, Pisello AL, Nicolini A, Filipponi M, Palombo M. Analysis of retro-reflective surfaces for urban heat island mitigation: A new analytical model. Applied Energy. http://dx.doi.org/10.1016/j.apenergy.2013.10.038.
[11] Bonamente E, Rossi F, Coccia V, Pisello AL, Nicolini A, Castellani B, Cotana F, Filipponi M, Morini E, Santamouris M. An energy-balanced analytic model for urban heat canyons: comparison with experimental data. http://dx.doi.org/10.1080/17512549.2013.865561.

Excavations at the Villa San Marco, Castellammare di Stabia (2012)

Joe Sheppard

Columbia University,
PhD student in Classical Studies
js3684@columbia.edu

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APAHA

Archaeology

Columbia University

Abstract

This report summarizes the findings from two seasons of excavations at the Villa San Marco in Castellammare di Stabia. The results of the fieldwork shed light on the infrastructure supporting the industrial courtyard (e.g. water supply, storage tanks, drainage, and work surfaces) as well as on the earliest habitation in the area. The new cultural material unearthed pushes back the date for human activity at least five centuries before the construction of the Roman Imperial villa.

1. Introduction / Background Information

In the summer of 2012, the Advanced Program of Ancient History and Art (APAHA) – a partnership between Columbia University, the Italian Academy, La Sapienza - Università di Roma and the Honors Center of Italian Universities (H2CU) – resumed fieldwork for a second season at the Villa San Marco in Castellammare di Stabia, Italy. Under scientific directors Prof. Francesco de Angelis and Prof. Marco Maiuro (Columbia) and field director Prof. Taco Terpstra (Northwestern University), an international team of students pursued key research questions about the dating and phasing of the Roman Imperial Villa there, which was buried by the eruption of Mount Vesuvius in AD 79. The excavations comprised trenches in the northern courtyard of the villa and also in the adjacent street that had led in ancient times from the coastline nearby towards the urban settlement called Stabiae (fig. 1). While still preliminary, the results are encouraging, clarifying the function and excavation history of the space, suggesting an interesting pattern of habitation in the area and leading us to exciting new research questions. In addition, the excavations were supplemented with field trips to compara-

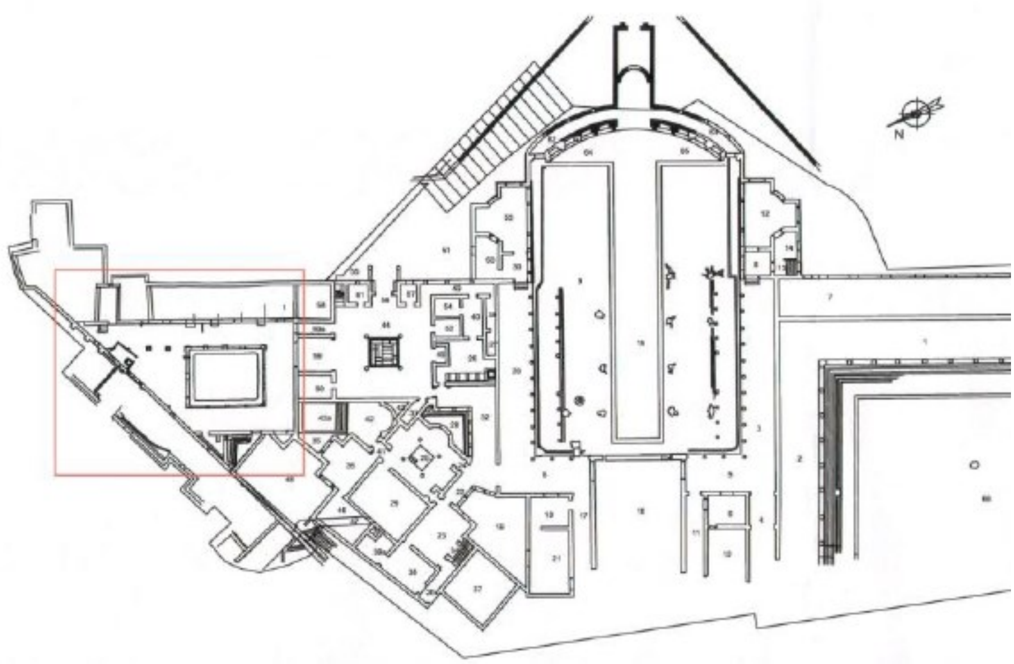

Figure 1: Plan of the Villa San Marco, Castellammare di Stabia, with a red box drawn around the courtyard and adjacent street. The atrium is just south of the red box, and the two triangular latrines are back to back, just west of the square forming the centre of the courtyard; the third triangle just to the south is one of the tanks. The street continues to the east but to the west is a steep staircase and sharp drop where the ancient coastline began.

ble sites in southern Italy, since the educational goals of the APAHA are not limited by rigid geographical or disciplinary boundaries.

2. Materials and Methods / Procedures

The key method employed was stratigraphic excavation, a procedure that seeks to place in chronological sequence every architectural feature, underground deposit, and event identified on site. Once this sequence has been established, it is then possible to narrow down potential dates for phases of human activity by analysing the cultural material found within each particular unit, such as sherds of pottery, masonry techniques or coins, all of which exhibit well-documented changes over time. Therefore all spoil excavated was passed through a uniform sieve (one centimeter square), so that any evidence for human culture could be removed, recorded, cleaned as appropriate, and stored safely for future analysis. Both qualitative and quantitative data of excavated materials were recorded in standardized templates, which were supplemented by photographs of each stratigraphical unit in its physical context, as well as plans and sections drawn from survey. Such careful and consistent record-keeping is essential because excavation is an inherently destructive practice. At the end of the season the site must be backfilled with all of the soil removed from the trenches, and thus no trace of our work remains outside of the information and artifacts we have collected, and the publications written from those.
In order that all archaeologists might have a broad knowledge of the local topography and history, as well as a closer understanding of related sub-disciplines (such as ceramics, environmental analysis and surveying), APAHA also included an educational program of both field trips to comparable neighbouring sites and seminars in specialized topics after hours. Such sites included the nearby ruins of Pompeii and Herculaneum, and other Roman Imperial Villas in Stabiae and Oplontis. These trips were largely Socratic in method, while the seminars covered both theoretical and practical aspects of each topic. Such an interdisciplinary approach offers real advantages, bringing greater confidence, accuracy, mindfulness and efficiency to archaeologists working in the field, and leading to more productive collaborations between the various individuals and projects working in the area.

3. Results

One consequence of the fieldwork was to clarify the excavation history of the area, which had been published only partially in recent years and barely at all during the earliest excavations of the site in the 1740s. The trenches in the northwest and southwest corners of the courtyard confirmed a series of industrial tanks and subterranean channels, as well as a rough and rambling tunnel that appears to have been dug the length of the courtyard by the original excavators working for Charles of Bourbon, the King of Naples and Sicily in the mid-18th century. We were thus able to reconstruct in detail the water supply and drainage during the final years of the villa and to identify several different phases of building activity in the courtyard, beginning with the northern wall of the villa and including at least two further periods of industrial production in each of the corners excavated.

In the street the trench was excavated down to the level of natural soil, which means that all levels of human culture were extracted and recorded. In the deepest deposit, evidence was found dating to the Archaic period (ca. 750-480 BCE), including fragments of what appeared to be black-figure pottery and local impasto vessels, along with glazed roof tiles. These finds suggest a very early phase of habitation in the area involving international trade and perhaps large-scale community organization, which had only been hinted at previously by the archaic necropolis nearby in Gragnano. Even though the road appears never to have been paved and its precise uses remain unclear, it seems safe to conclude that it preceded the Villa San Marco and the villa on the other side, which is important for understanding the development of the area.

4. Discussion / Analysis

The work in 2012 continued excavations from the previous summer in the courtyard. This area of the villa was originally selected for preliminary excavation because it is located at the intersection of where the public space of the neighbouring street meets a private household, and where the largely orthogonal orientation of the villa converges at an oblique angle with the bath complex and the adjacent street (fig. 1): it is therefore the ideal location to understand the relationships between either side of each of these two boundaries. The arrangement of the rooms in the courtyard also required explanation, with the monumental and grandly decorated entrance hall of the household directly adjacent to this more humble, undecorated courtyard, its beaten-earth floor and ready street access.
A trench was placed in the road to investigate both the external walls of the adjacent villas and the street leading to the town of Stabiae, which sources tell us had been destroyed during the Social War that Rome fought against her Italian allies (90-88 BCE). The only remaining material evidence of this settlement is the plan that the Bourbon excavators draughted before reburying the site in the 18th century. However, no stratigraphic excavations of the Roman villas and town of Stabiae predating the eruption of Mount Vesuvius have ever been published, and so this project has little in the way of local comparanda to drawn upon for ideas about public works, civic organization and private habitation in the area, beyond what is known about the standing villas of 79 CE. The conventional assumption that the villa was constructed some time in the first century BCE stems from a preliminary analysis of the masonry techniques, wall decoration and other material found in the nucleus of the villa, but this needs to be tested thoroughly in order to establish more precise dates for the different phases of the villa and to understand the villa in relation to the town and other public spaces. In the courtyard (figs. 2, 3), intervention by the Bourbon excavators presented difficulties because the stratigraphic sequence had been interrupted in the process. They appear to have dug a narrow tunnel that meandered and forked, with one arm running up the wall into an industrial tank in the courtyard, another passing beneath the threshold of the nearby latrines, and the final one leading through the wall into a plunge pool (fig. 3) – destroying everything in their way in the process. These characteristics led us to deduce that the purpose of the tunnel was to despoil a series of lead pipes

and fittings that coursed through these cavities. Such a hypothesis fits with the excavation practices of the time, long before the method of stratigraphy had been developed, when the local authorities were generally seeking objects of maximum financial or cultural value. It was therefore possible for us to reconstruct a plausible model of the water supply and drainage in the area, with the channels flushing out the adjacent latrines and removing waste from the courtyard and the nearby pools in the atrium and baths. This pattern of ancient industry and early modern interventions corresponded with a similar series of features unearthed in the northwestern corner of the courtyard.

The working narrative for the courtyard area thus consists of several phases of industrial production, involving one of the long drainage channels and at least two deep tanks that were subsequently destroyed or modified before the creation of the other channel and the construction of the courtyard's parapet walls and columns – which rest, in fact, on top of the walls constructed for the earlier tanks and channels. This hypothesis accords with the overall lack of decoration in the space, the enormous and well-worn limestone mortar found here, the immediate access to the street and the restrictive magazine rooms on the eastern side that still need to be excavated, as well as

Figure 2: View from inside the northeast quadrant of the courtyard area, looking north towards the exterior wall of the villa and the passage to the street at right. In the background students excavate small pumice stones from the trench already dug by the Bourbon excavators over 250 years ago. Copyright 2011 Jens Haas

Figure 3: elevated view from just outside the southern parapet wall of the courtyard, looking west towards a triangular tank (at left) and doorway to the latrines (behind pillar), and showing the point where the narrow underground channel draining the atrium enters from the south and feeds into the larger channel (running left to right in the centre of the image). A shallow, narrow recess is visible sloping upwards and to the south from the threshold of the latrines -- one of several places where it seems clear that 18th-century excavators extracted pipes for their lead content.

comparable structures in other contemporary villas of the region. However, the exact type, range and scale of activities taking place here still remains unclear.
In the street bright paleosols were found sloping down sharply to one side, suggesting some kind of quarrying event (fig. 4). The Archaic ceramics and building materials partially filled this cavity, deposited perhaps as early as the 6th century. Above these layers thin patches of beaten-earth surfaces were found, but very little in the way of material culture from the intervening centuries between this earliest phase and the construction of the villa in the first century BCE. This curious gap could be explained by a large-scale landscaping event in order to prepare a terrace for the villas on either side, or else combined with the nature of the Archaic finds and the path to offer an alternative working hypothesis of an early extra-urban structure and its land being put out of commission, and subsequently abandoned or used for agriculture for centuries before the neighbouring villas were built. At this point, the path became convenient because it allowed a second entrance to the villa, one that led down to the bay below.

Figure 4: Students analyze the eastern section of the trench in the street. The yellowish paleosol is visible towards the top of the photo and slopes down into the shadows. The only surfaces found were packed rather than paved. The rubble at the top of the photo is a drain built against the foundations of the villas northern wall. Photo: A. Garcia.

5. Future work

The next step is to analyse the ceramic remains and environmental samples in order to confirm the current hypotheses about the stratigraphic sequence, dating and use of each area. Possible future initiatives would include unearthing the magazine rooms immediately to the east of the courtyard, and the comprehensive measurement and analysis of all floors and standing architecture in the villa. Further trenches could be opened at key locations in the courtyard, such as the point at where the monumental entrance hall leads into the area, in order to test the relationship between the two areas and continue mapping the water supply and drainage. The pattern of habitation suggested by the material remains in the street could be tested in sondages further uphill, an area less likely to have been cleared away without leaving any traces, and the area just beneath the stairs at the end of the street might also shed light on how long the path has been used for maritime access. Further investigation of the deepest stratigraphic layers is needed in the street and elsewhere because not all of the Archaic material was able to be recovered due to logistics. The building immediately to the north of the street also warrants further excavation because it seems to have communicated with the Villa San Marco by an elevated passage on top of the arched gateway, essentially bridging these two structures that had previously been thought to be discrete entities.

6. Acknowledgements

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7. Bibliography

D'Orsi, L. 1996, *Gli scavi di Stabiae: Giornale di scavo (a cura di Antonio Carosella)*, Rome.

Ruffo, F. 2009, "Sulla topografia dell'antica Stabiae. Osservazioni sulla Villa San Marco e sul cosiddetto impianto urbano alla luce delle recenti indagini archeologiche (2008-2009)", in *Oebalus: Studi sulla Campania nell'Antichità*.

Ruggiero, M. 1881, *Degli Scavi di Stabiae dal MDCCXLIX al MDCCLXXXII*. Naples.

Terpstra, T. T., Toniolo, L., and Gardelli, P. 2011, "Campagna di scavo APAHA 2011 a Villa San Marco, Stabiae: relazione preliminare sull'indagine archeologica", in *Rivista di Studi Pompeiani* 22: 199-205.

Terpstra, T. T. 2012, "The 2011 Field Season at the Villa San Marco, *Stabiae*: Preliminary Report on the Excavations", in *Fasti Online Documents & Research* No. 259: 1-11.

_______. 2013, "The 2012 Excavation Season at the Villa San Marco, *Stabiae*: Preliminary Field Report", in *Fasti Online Documents & Research* No. 286: 1-7.

Fluorescent Particle Tracer for Surface Hydrology

Flavia Tauro[1-2]

[1] *Sapienza University of Rome,*
Dipartimento di Ingegneria Civile, Edile e Ambientale,
Rome, Italy
[2] *NYU Polytechnic School of Engineering*
Department of Mechanical Engineering, Brooklyn,
United States of America
ft461@nyu.edu

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fluorescence

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flow measurement

Abstract

Traditional environmental monitoring methodologies do not allow for accurately characterizing surface flows in natural environments. Specifically, they are typically based on intrusive experimental procedures, require physical sampling, and provide measurements at a limited number of locations in natural catchments. To mitigate limitations of conventional hydrological surveying techniques, in this work, we provide an overview of a novel tracing system for surface flow observations. This methodology is based on the deployment of high visibility buoyant tracer particles in the environment and on their remote acquisition through inexpensive digital video cameras. The tracer particles are detected and tracked in acquired images through ad hoc image-based analysis algorithms. The proposed methodology allows for nonintrusive and potentially continuous observations in the environment. Further, ongoing efforts are being devoted to its integration on unmanned aerial vehicles for large scale monitoring in natural settings.

1. Introduction

Surface hydrological processes control downstream runoff phenomena [Chow et al., 1988; Bras, 1989], waste and pollutant diffusion [Bansal, 1971], erosion mechanics [Piccarreta et al., 2006; Wainwright, 1996], and sediment transport [Kondolf and Piégay, 2003; Rulli and Rosso, 2005]. These flows are largely dominated by ephemeral microchannel drainage networks in hillslope areas [Chirico et al., 2007; Gasparini et al., 2004; Istanbulluoglu et al., 2008; Tucker and Bras, 1998]. A quantitative understanding of the flow physics in these areas is currently limited by the lack of effective tracing techniques suitable for basin-scale observations [Leibundgut et al., 2009]. Specifically, traditional tracers include isotopes, chemicals, floating objects, and dyes. Natural substances, such as water isotopes, are sampled and analyzed through complex laboratory processes to infer water age. On the other hand, artificial tracers, such as chemicals, floating objects, and dyes, require the presence of operators for deployment and sampling in the environment. Due to dilution and dispersion, massive quantities of such materials are needed for investigating rather limited stream reaches and watershed sections, thus severely affecting water quality, ecosystem health, and experimental costs. On the other hand, field experiments require environmentally resilient, non-invasive, and low cost measurement systems that can potentially operate in remotely-controlled or unmanned conditions. Furthermore, water turbidity, flow path heterogeneity, and natural flow obstructions impose severe constraints on sensing technologies in field studies [Jodeau et al., 2008; Kim et al., 2008].

In this work, we propose a novel tracing methodology for surface hydrology measurements in natural environments. This innovative technique combines the efficiency and versatility of traditional conceptions while improving their practical feasibility. Specifically, this tracing methodology can be applied to a variety of real-world settings spanning from small scale streams to few centimeter rills in natural hillslopes. The sensing system is based on the detection and tracking of 100 -- 3000 μm fluorescent spheres through digital cameras for direct flow measurements. Advantages of this methodology with respect to more established technologies rely on the particles' insolubility (which allows for limiting the tracer dispersion from adhesion to natural substrates, thus minimizing the amount of tracing material), high visibility (which leverages nonintrusive tracer detection), and low cost. In particular, this automated technology is inherently designed to provide continuous measurements in complex flows, such as shallow water streams, overland flows, and mountainous creeks.

Here, we report the main findings obtained from feasibility studies on the implementation of the proposed sensing system in natural settings as well as future scientific questions and research directions.

2. Materials and Methods

Particle Tracers

Two classes of fluorescent particles are used as hydrological tracers. Notably, the use of insoluble particles allows for minimizing the amount of material to be deployed in the environment. In addition, the high visibility of the tracer leverages its automated sensing through inexpensive digital acquisition devices. Specifically, off-the-shelf yellow-green and red fluorescent spheres are purchased from Cospheric LLC [Cospheric, 2010], Figure 1.
Particles are fabricated by embedding the fluorophore into a polyethylene matrix. Whereas this allows for a lasting and intense luminescence, the deployment of massive quantities of polyethylene can be harmful to the environment. The particles are slightly buoyant and spherical thus allowing for enhanced flow tracing performance. A thorough characterization of the visibility of the particles in laboratory controlled conditions, that is, in dark environments and static turbid water, is documented in [Tauro et al., 2010].

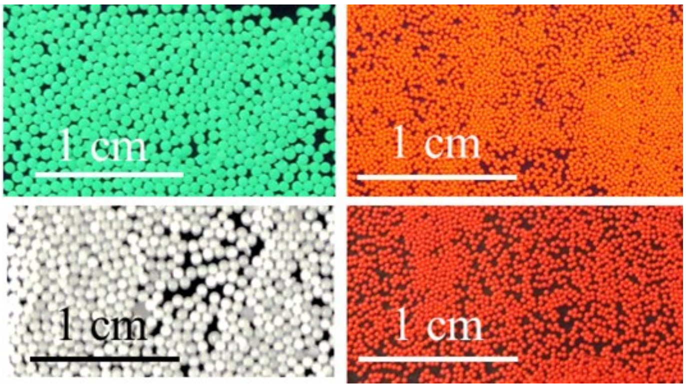


Figure 1 – Left, yellow-green and right, red fluorescent particles under UV light (top) and sunlight (bottom).

Data Processing

Due to the complexity of the experimental settings, images depicting the fluorescent particle transit frequently present inhomogeneous background and noise from water reflections. Further, high flow regimes often result in irregularly shaped particles. Such adverse conditions have mandated the development of ad-hoc custom-built algorithms for particle sensing. The transit of the particle tracers is captured through commercially available digital acquisition systems and then detected by analyzing relative images. Several image analysis tools are developed in [Tauro et al., 2010, Tauro et al., 2012] to infer particle motion. Specifically, in [Tauro et al., 2010] an aggregated index is defined to quantify the bead visibility against image background. The index corresponds to a weighted difference between intensity histograms corresponding to the particle image and the corresponding background. Analysis of sequences of images by such methodology allows for identifying the brightest frames in recorded videos, thus detecting the beads' transits in the absence of severe light reflections.

Particle tracking and detection in natural conditions is performed through a custom-built algorithm, see [Tauro et al., 2012]. This procedure takes advantage of the known oblate shape of the particle as it appears in frames acquired through commercially available camcorders and implicitly assumes that the particle follows a rectilinear trajectory as it crosses the area of interest. The algorithm is based on the correlation between a template image and frames extracted from the videos, that is, particle location is assimilated to the maximum of the correlation coefficient, see Figure 2.

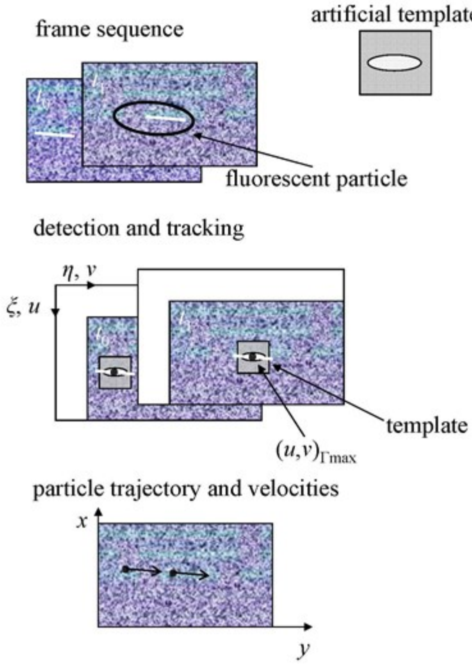


Figure 2 – Schematic of the particle tracking algorithm.

The correlation analysis is sharpened by preprocessing the images from experiments by a background subtraction. The algorithm integrates a conditional updating procedure which allows for enhanced detecting performances. The velocity of the potential particle in the plane is estimated by collecting the locations where correlation peaks are attained.

Conditional tests on maximum particle acceleration and motion transverse to the flow direction are also used to avoid false readings.
Further methodologies to extract the particle velocity and infer flow regime are documented in [Tauro et al., 2013, Tauro et al., 2013a]. In particular, Particle Image Velocimetry algorithms are used to estimate flow velocity of natural streams in [Tauro et al., 2013] and a manifold learning framework is proposed in [Tauro et al., 2013a] for unsupervised characterization of complex fluid flows.

3. Results

Preliminary studies on the detectability of off-the-shelf fluorescent tracer particles in turbid and clear water conditions, dark and illuminated environments, and fluids that are either quiescent or in motion are reported in [Tauro et al., 2010, Tauro et al., 2012]. These studies have provided a first demonstration of the feasibility of in-situ flow tracing through fluorescent particles. In these preliminary efforts, particle tracers are detected by estimating their fluorescence emissions through the use of photoresistors and video feed analysis. Experimental findings show that particle fluorescence is visible for a broad range of depths of the tracers with respect to the water surface and in case of high turbidity. Interestingly, in case of beads floating on the surface of suspensions, turbidity has a beneficial effect by increasing the particle-to-background contrast, thus substantiating the actual tories can be tracked when they pass underneath the sensing apparatus, see Figure 3.

Further, travel time experimental results emphasize the enhanced performance of the particles with respect to traditional tracers. In particular, the fluorescent particles' size and good visibility allow for optimal tracking in adverse flow and

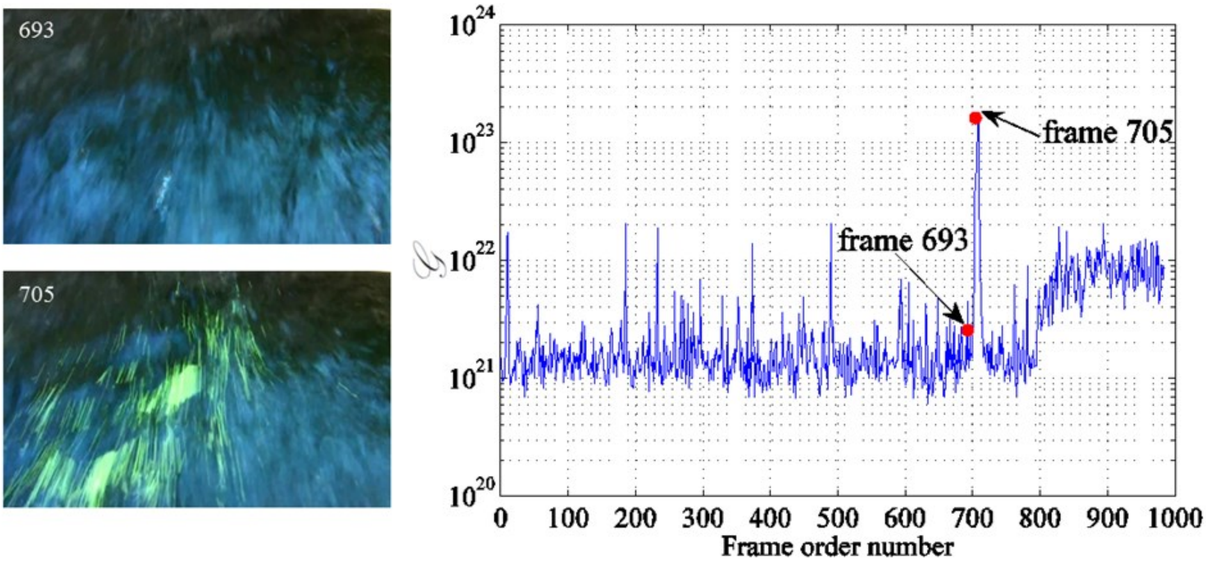


Figure 3 – Left, color frames extracted from a video depicting the fluorescent particles transiting in the Rio Cordon and right, aggregated index time series for the video.

use of such particles in practical conditions.

Resting on favorable findings obtained in preliminary laboratory tests, the transition of the methodology to field studies has been assessed through proof-of-concept outdoor experiments in a natural stream and a semi-natural hillslope [Tauro et al., 2012a, Tauro et al., 2012b]. Specifically, the feasibility study for natural settings is conducted in the Rio Cordon natural mountainous stream in the Italian Alps by using off-the-shelf Cospheric LLC green fluorescent particles. The stream presents a step and pool bed with a 13% mean slope and whose width is approximately 5--6 m wide.

Two classes of experiments are conducted, that is, flow measurement experiments at a selected stream cross section and travel time experiments (that is, the time tracers take to travel along a stream reach of known length is estimated) on stream reaches as long as 30 m. Flow measurements are performed to estimate the flow velocity in an artificial section of the stream by deploying the fluorescent particles in proximity of an experimental apparatus (comprising a video camera and fluorescent lights) and then tracking their transit in the field of view of the camera. Travel time experiments are conducted for varying amounts of fluorescent particles deployed in natural stream reaches of different lengths. Image analysis tools presented in the Materials and Methods Section are used to detect the tracers. Further, an array of traditional tracers, including dye and several floating objects, is considered to benchmark the proposed approach against traditional tracing systems. Experimental findings demonstrate that, despite the minute size of the spheres, the relatively low camera acquisition frequency, and the high flow regime of the stream, individual fluorescent beads can be detected and their trajectories can be tracked when they pass underneath the sensing apparatus, see Figure 3.

illumination conditions, whereas bulky objects remain trapped in stream pools.

An additional overland flow feasibility study is performed on a semi-natural hillslope plot under high turbidity loads and soil and rain drops interaction with Cospheric LLC green fluorescent particle tracers. The experimental hillslope plot is located at the University of Tuscia, Viterbo, Italy, where ad-hoc experiments are performed to assess the visibility and detectability of the particle tracers in these severe environmental conditions and their feasibility in estimating overland flow velocities. Experiments are conducted by using particles of varying diameters ranging from 75 to 1180 μm. Travel time experiments are conducted by activating a rainfall simulator at the constant intensity of approximately 50mm/h to produce a water head of a few centimeters in the hillslope rill. For each experiment, a sample of 4 -- 5 g of particles of a selected diameter class is deployed at the rill onset at approximately 4 m from the detection apparatus. Once videos are taken, frames are processed to estimate surface flow velocity by the particle travel time, see Figure 4. Despite the adverse

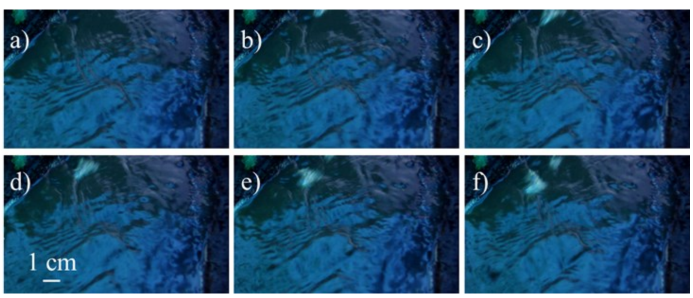


Figure 4 – Snapshots of the transit of 75 – 90 μm particles in the rill underneath the sensing station.

environmental conditions, experimental results support the feasibility of using fluorescent particles for environmental applications. In particular, the strengths of the methodology can be summarized as follows: (i) particles as small as 75 μm are detected through both supervised and unsupervised procedures; (ii) reliable velocity estimates are obtained for the largest sizes, that is, 1000 -- 1180 μm; and (iii) particle transits are successfully captured for most of the larger diameters and for 150 – 180 μm beads.

4. Discussion

Despite the adverse conditions encountered in the feasibility studies, experimental findings support the use of fluorescent particles for environmental applications. In particular, the proof-of-concept experimental campaign conducted in the Rio Cordon assesses the performance of the particle tracers in stream flow settings, where high velocity regimes, presence of foam, and light reflections pose serious challenges to bead detection. Further, the hillslope experiment posits the feasibility of the methodology under high turbidity loads and soil and rain drops interaction.

Although Cospheric LLC particles demonstrate a good detectability in laboratory conditions, their use in field studies is affected by a number of drawbacks, including: their high cost ranging from $1000 per kilogram to $300 per gram according to particle dimension and batch size; their limited degree of eco-compatibility due to their plastic polyethylene composition; and the impossibility of engineering their fluorescence, which may be needed to control their lifetime or to enhance the response. To address some of these issues, environmentally-friendly particle tracers have been in-house fabricated and used as experimental tracers in controlled laboratory and outdoor settings. Specifically, the beads are synthesized from nontoxic Fluorescent FWT Red Dye Concentrate, Cole Parmer®, and natural white beeswax pellets purchased from Stakich Inc., MI. The beads are environmentally friendly and their fluorescence spectra tailored to be highly visible under a broad excitation wavelength range. The particles are neutrally buoyant and spherical in shape and their cost is only 0.025 $/g. Eco-friendly particle characterization and experimental analyses are presented in [Tauro et al., 2012c, Tauro et al., 2013b, Tauro et al., 2013c].

5. Conclusions and Future Work

In this work, a novel sensing system has been proposed for surface hydrology. The methodology is based on the nonintrusive digital acquisition of fluorescence of particle tracers. Laboratory and field studies have demonstrated the versatility and ease of implementation of the methodology in complex settings.

Future research efforts, partially supported from the American Geophysical Union Horton Research Grant, will be addressed towards the development of an unmanned quadricopter for nonintrusive flow monitoring. The proposed sensing methodology will be implemented in the hydrological characterization of the mountainous Rio Cordon catchment, Italy. In particular, field experiments will aim at determining the watershed ephemeral drainage network; quantifying and kinematically characterizing relative water fluxes; and identifying connected areas and transport mechanisms from the hillslope to the channel.

Future efforts will also aim at answering the following scientific questions by using the developed sensing system:

- What are the main physical processes occurring on the surface of hydrological catchments? How do they contribute to the generation of the overall watershed regime?
- How is water transferred from the hillslope to the outlet in natural watersheds?
- Can water fluxes relative to such surface processes be traced and quantified?
- Can the kinematics of surface runoff processes inform the watershed response in time?

6. References

Chow, V.T., Maidment, D.R., and Mays, L.W. *Applied Hydrology*. McGraw-Hill, New York, 1988.

Bras, R.L. *Hydrology: An Introduction to Hydrologic Science*. Addison-Wesley, Lebanon, Indiana, 1989.

Bansal, M.K. Dispersion in natural streams. *ASCE Journal of Hydraulics Division*, 97(11):1867–1886, 1971.

Piccarreta, M., Faulkner, H., Bentivenga, M., and Capolongo, D. The influence of physico-chemical material properties on erosion processes in the badlands of Basilicata, Southern Italy. *Geomorphology*, 81(3-4):235–251, 2006.

Wainwright, J. Infiltration, runoff and erosion characteristics of agricultural land in extreme storm events, SE France. *Catena*, 26(1-2):27–47, 1996.

Kondolf, M.G. and Piégay, H. editors. *Tools in Fluvial Geomorphology*. John Wiley & Sons, West Sussex, UK, 2003.

Rulli, M.C. and Rosso, R. Modeling catchment erosion after wildfires in the San Gabriel Mountains of Southern California. *Geophysical Research Letters*, 32(19):L19401, 2005.

Chirico, G.B., Medina, H., and Romano, N. Uncertainty in predicting soil hydraulic properties at the hillslope scale with indirect methods. *Journal of Hydrology*, 334(3-4):405–422, 2007.

Gasparini, N.M., Tucker, G.E., and Bras, R.L. Network-scale dynamics of grain-size sorting: Implications for downstream fining, stream-profile concavity, and drainage basin morphology. *Earth Surface Processes and Landforms*, 29 (4):401–421, 2004.

Istanbulluoglu, E., Yetemen, O., Vivoni, E.R., Gutierrez-Jurado, H.A., and Bras, R.L. Ecogeomorphic implications of hillslope aspect: Inferences from analysis of landscape morphology in central New Mexico. *Geophysical Research Letters*, 35(14):L14403, 2008.

Tucker, G.E. and Bras, R.L. Hillslope processes, drainage density, and landscape morphology. *Water Resources Research*, 34(10):2751–2764, 1998.

Leibundgut, C., Maloszewski, P., and Külls, C. *Tracers in Hydrology*. Wiley-Blackwell, Oxford, UK, 2009.

Jodeau, M., Hauet, A., Paquier, A., Le Coz, J. and Dramais, G. Application and evaluation of LSPIV technique for the monitoring of river surface velocities in high flow conditions. *Flow Measurement and Instrumentation*, 19 (2):117–127, 2008.

Kim, Y., Muste, M.V.I., Hauet, A., Krajewski, W.F., Kruger, A., and Bradley, A.A. Stream discharge using mobile large-scale particle image velocimetry: A proof of concept. *Water Resources Research*, 44(9):1--6, 2008.

Cospheric LLC, http://www.cospheric-microspheres.com/default.asp (2010).

Tauro, F., Aureli, M., Porfiri, M., and Grimaldi, S. Characterization of buoyant fluorescent particles for field observations of water flows. *Sensors*, 10(12): 11512–11529, 2010.

Tauro, F., Pagano, C., Porfiri, M., and Grimaldi, S. Tracing of shallow water flows through buoyant fluorescent particles. *Flow Measurement and Instrumentation*, 26:93-101, 2012.

Tauro, F., Grimaldi, S., Porfiri, M., and Petroselli, A. Fluorescent particles for non-intrusive surface flow observations. *Procedia Environmental Sciences*, 19:895-903, 2013.

Tauro, F., Grimaldi, S., and Porfiri, M. Unraveling flow patterns through nonlinear manifold learning. *PLoS ONE*, 9 (3):e91131.

Tauro, F., Grimaldi, S., Petroselli, A., and Porfiri, M. Fluorescent particle tracers for surface flow measurements: a proof of concept in a natural stream. *Water Resources Research*, 48(6):W06528, 2012.

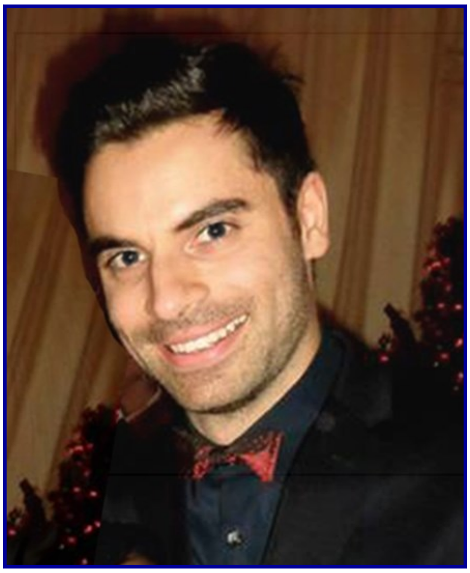
Tauro, F., Grimaldi, S., Petroselli, A., Rulli, M.C., and Porfiri, M. Fluorescent particle tracers in surface hydrology: a proof of concept in a semi-natural hillslope. *Hydrology and Earth System Sciences*, 16(8):2973--2983, 2012.

Tauro, F., Mocio, G., Rapiti, E., Grimaldi, S., and Porfiri, M. Assessment of fluorescent particles for surface flow analysis. *Sensors*, 12(11):15827-15840, 2012.

Tauro, F., Porfiri, M., and Grimaldi, S. Fluorescent ecoparticles for surface flow physics analysis. *AIP Advances*, 3 (3):032108, 2013

Tauro, F., Rapiti, E., Al-Sharab, J.F., Ubertini, L., Grimaldi, S., and Porfiri, M. Characterization of eco-friendly fluorescent nanoparticles doped-tracers for environmental sensing. *Journal of Nanoparticle Research*, 15(9):1884, 2013.

PopUps Interview with Dario Feliciangeli



Name: Dario Feliciangeli

Where are you from? Roma, Italy

Where do you work now? HNTB New York Office Bridge Department

What is your position? Bridge Engineering

Your story: At the end of my Italian degree in Ingegneria Edile Architettura I chose to complte my studies in NY. H2CU gave me the opportunity to do it, offering me an apt in Ny for the entire duration of my MS. I went to Columbia University to do a M.S in Civil Engineering with focus on design of Large Scale Structures. Attending the Bridge design class I met professor Ted Zoli, who is the national bridge technical leader at HNTB Corporation, one of the best design firm in U.S.A. At that time my desire was to join him to work together and continue the relationship established at school. Right now we work together, trying to make real ideas we agreed in school.

Your accomplishments: I had the chance to be involved in the design of Squibb Park Bridge, New York NY

http://www.brooklynbridgepark.org/the-park/squibb-park-bridge

Mockingbird Pedestrian Bridge, Dallas TX http://www.dallasnews.com/news/metro/20130617-groundbreaking-tuesday-on-mockingbird-pedestrian-bridge-at-katy-trail.ece

http://cityhallblog.dallasnews.com/2013/05/before-angela-hunt-leaves-office-a-parting-gift-breaking-ground-on-the-katy-trails-mockingbird-pedestrian-bridge.html/

Tulsa Riverfront Park Bridges, Tulsa, OK http://agatheringplacefortulsa.com/get-the-visuals/

Portal Bridge, Secaucus NJ http://newyork.construction.com/new_york_construction_news/2011/0426_NJPortalBridge.asp

PopUps Interview with Matteo Montesi

Name: Matteo Montesi

Where are you from? Rome, Italy

Where do you work now? Parsons Brinckerhoff

What is your position? Geotechnical Engineer II

Your story: I graduated in 2008 with a BS and MS in Envinronmental Engineering from University of Rome "Sapienza". Afterwards, I immediately departed to New York City, eager to explore the many opportunities that H2CU was giving me through their program. I enrolled in a MS in Civil Engineering at Columbia University, where I graduated after 1 year, in February 2010. I joined PB in March 2010, and I have been part of this successful engineering firm for almost 4 years now. During 4 years I have been exposed to a variety of projects, going from tunnels, to bridges, to railroads, highways, and marine structures. It has been and it still is an incredible learning and rewarding experience to work in the NYC metro area for this important company.

Your accomplishments: My most important accomplishments while in the US have been graduating in 2 semesters with a GPA of 3.9, being promoted to Geotechnical Engineer II after having been with PB for only 2 years, and eventually (I will know the results in a month or so) having obtained the Professional Engineering license (PE) from California state.

PopUps Interview with Elisabetta Natale

Name: Elisabetta Natale

Where are you from? Pavia, Italy

Where do you work now? Parsons Brinkerhoff, Orlando, FL

What is your position? Water Resources Engineer II

Your story: I am an environmental engineer with a background in civil and environmental engineering. I obtained my BS and MS at University of Pavia and thanks to H2CU I had the opportunity to attend and achieve a Master of Engineering in Environmental Engineering at the Massachusetts Institute of Technology (MIT) in Boston. When I was completing my studies at MIT, before graduating, I attended a career fair and contemplated to start a career in the United States. My first job interview brought me to Orlando, Florida, where I have been working since 2010 for Parsons Brinckerhoff's Water Technical Excellence Center.

Your accomplishments: Working in the water resources filed gives an opportunity to delve with a great range of aspects, including water supply planning, wastewater planning and design, stormwater management, integrated water resources planning, hydraulic modeling and many others. Since day one, I have had the opportunity to work on dozens of projects dealing with such a great variety of fields, where I experienced the technical aspects and also the client relationship and project management sides. Today, even though the technical aspects and the "real engineering" are always a fundamental part of my job, I am focusing my career in the projects and clients management, and I am currently the project manager of 5 projects and deputy project manager of 6.

PopUps Interview with Alfonso Oliva

Name: Alfonso Oliva

Where are you from? Cassino (FR), Italy

Where do you work now? Thornton Tomasetti (NY)

What is your position? Senior Engineer

Your story: Everything started back in Cassino where I received my Bachelor's Degree in Civil Engineering from the Universita' degli Studi di Cassino, while working as a professional surveyor, 3D modeler and animation expert. After winning a national scholarship in 2009, I moved to the United States to complete a Master's Degree in Structural Engineering at New York University in Manhattan. I earned a second Master's Degree in Civil Engineering from the Universita' degli Studi di Cassino, and conducted a 6 months thesis research on Rafael Moneo's Northwest Corner building at New York's Columbia University. I'm currently working for Thornton Tomasetti in NYC in the Advanced Computational group where besides working on the design of arenas and tall buildings I apply my expertise in both structural design and computer science to develop applications that speed up and overcome complex design processes; I also work close to assist Artists in designing sculptures and special structures. I'm currently on my way to complete my 3rd Master's Degree in Product of Architecture and Engineering at Stevens Institute of Technology in Hoboken, NJ. When not working, I enjoy Art and Photography, specializing in portraits and architectural photography.

Your accomplishments: First is the H2CU scholarship I received back in 2009; thanks to that my career path became suddenly more interesting. Work wise I took part in the design of some of the most interesting projects all over the world, from stadiums to tall buildings- Hudson Yards by KPF, Edmonton Arena by 360 Architecture and a complex roof design for the USF by Santiago Calatrava are some example of the projects I've been involved in the past 2 years. Being part of a group interested in research and new technologies I'm currently working on a tool for optimization of tall buildings under lateral loads that I'll be showcasing in the next ASCE 2014 Structures Congress in Boston, Massachusetts.

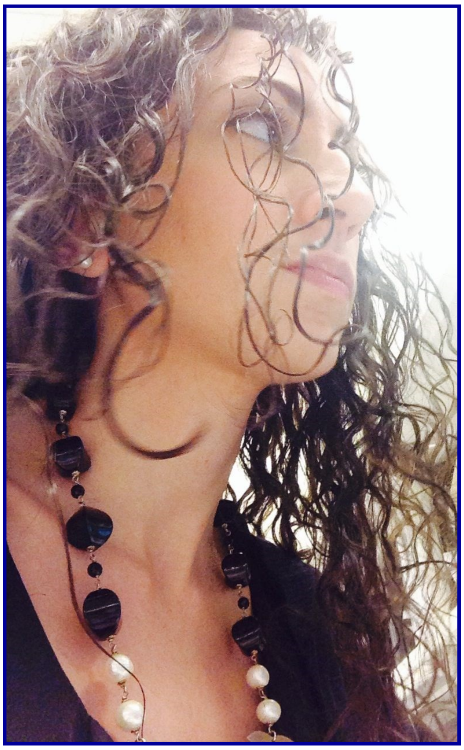
PopUps Interview with Enrica Oliva

Name: Enrica Oliva

Where are you from? Cassino (FR), Italy

Where do you work now? Thornton Tomasetti (NY)

What is your position? Project Engineer



Your story: I am one of the "Veterans" of the H2CU Program. I came to NY with the very first Scholarship, in January 2006. I had graduated from University of Cassino in January 2004 “Magna Cum Laude” in Civil Engineering and had almost completed my Laurea Specialistica in Structural Engineering by the time I left Italy. I attended the 1st semester, and after the Final Exams I went back Home. There I took my last Exam and defended my Thesis for the “Laurea Specialistica” in July 2006, again “Summa Cum Laude”. I proposed a redesign of the New York Times Tower by Renzo Piano with a different structural system. My Work was presented verbally to the Committee and the audience in Italian, but the document was available both in English and in Italian. Once back in NY in September, I finished the Grad Classes and got my M.S. Degree at COLUMBIA UNIVERSITY in December 2006, with a GPA of 3.95 By that time I had already gotten several job offers in NYC. I decided to take the one from Thornton Tomasetti, based on the great reputation of the Firm, their many accomplishments in designing the tallest buildings in the world, many sports arenas, and thanks to the positive experience I had taking their “Large Scale Building Design” class at COLUMBIA. I've been at the Firm for 7 years, working on several extremely challenging projects, both in steel and concrete, within the NYC area as well as elsewhere in the US and Canada.

Your accomplishments: I started my Career as an Entry Level Engineer in February 2007, working on Frank Gehry's "Tower 1" in Brooklyn: a 35-story tower with all sloping columns, twisting floor slabs, an extremely complex steel Vierendeel Truss structure and a concrete core. I got promoted to Senior Engineer in July 2009 and worked on projects like The Hudson Yards Development, the Barclays Center Arena, the Extension of the #7 train to the west side of Manhattan, the Ridge Hill Mall, as well as on smaller-scale projects such as renovations of existing buildings, addition of several floors to existing structure (330 Hudson Street, to name one). In July 2013 I was promoted to Project Engineer: I am currently involved in the design of the W57th Street Pyramid Tower, the Regeneron Lab Buildings in Tarrytown NY, the new Headquarters for SGI USA in Brooklyn, and the Wishard Commons in Indianapolis, IN.

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H2CU Headquarters

Engineering School, Sapienza University of Rome, Via Eudossiana 18, 00184 Rome Italy
NY Office at PACE University, one Pace Plaza, room Y21, New York City, NY 10038

Contacts

www.h2cu.com; secretary@h2cu.it
phone: +390644585069 — fax: +390644585027