

IREE:Automated Vision Tracking of Project Related Entities

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ABSTRACT:

The purpose of this supplemental project was to collect invaluable data from the large-scale construction sites of Egnatia Odos motorway needed to validate a novel automated vision-tracking method created under the parent grant. For this purpose, one US graduate and three US undergraduate students traveled to Greece for 4 months and worked together with 2 Greek graduate students of the local faculty collaborator. This team of students monitored project activities and scheduled data collection trips on a daily basis, setup a mobile video data collection lab on the back of a truck, and drove to various sites every day to collect hundreds of hours of video from multiple cameras on a large variety of activities ranging from soil excavation to bridge construction. The US students were underrepresented students from minority groups who had never visited a foreign country. As a result, this trip was a major life experience to them. They learned how to live in a non-English speaking country, communicate with Greek students, workers and engineers. They lead a project in a very unfamiliar environment, troubleshoot myriad problems that hampered their progress daily and, above all, how to collaborate effectively and efficiently with other cultures. They returned to the US more mature, with improved leadership and problem-solving skills and a wider perspective of their profession.

INTRODUCTION

National Science Foundation awarded the University of Michigan, Grant # 0625643 for the Project-Automated Vision Tracking of Project Related Entities.

This project aims to test the feasibility of a novel method to track project related entities such as personnel, material and equipment in 4D (spatial coordinates and time) is being developed with the help of this grant. Under this technique, self-calibrated cameras will be used to collect video streams. Project related entities are automatically recognized using previously developed pattern recognition techniques. These entities are

tracked in 2-D and 3-D. Until now, 2-D and 3-D tracking of construction personnel by identifying hard hats has been developed. Tracking algorithms were tested and produced promising results. Research is also being done to auto-calibrate cameras so that these cameras can be used on site to track entities with better, effective results.

A significant part of this project is the validation of the proposed method on a real construction site. For this purpose, it is necessary to get video data from large scale, high diversity, and high flow of material, equipment sites to measure the performance of the algorithm that is developed. Egnatia Odos motorway, budgeted at \$ 8 billion is a large project that would have parallel activities at different sites, and high diversity in operations. This project has 670km long highway project will have 1650 bridges, 74 tunnels and 50 road interchanges. It would provide service to 36% of the population, 54% of farmlands and 41% of the manufacturing industry (Egnatia '07). USA, being a developed nation has primarily infrastructure maintenance projects so, it could not provide for the large-scale test-bed required for the performance testing of the tracking algorithm. For this purpose, one US graduate student and three undergraduate students were selected to obtain videodata from synchronous cameras at the Egnatia Odos motorway. This project offered an exceptional opportunity to simultaneously perform large scale tracking and monitoring tests required for the current award on a variety of heavy traffic construction sites. Professor Demos Angelides, Chairman of School of Engineering at Aristotle University of Thessaloniki was the foreign collaborator on this project. He served as a local advisor to the students from University of Michigan. With his help, we were able to get access to the active projects at the Egnatia Odos motorway.

Mr. Córdova a Latino US citizen and a resident of Puerto Rico was selected as the project leader for this supplemental project. He graduated from University of Puerto Rico at Mayaguez with Civil Engineering degree and then was a MS student at University of Michigan. He was doing research on the current award project. This supplemental project helped him contribute more to his research and help obtain invaluable data for the validation of his research. Undergraduate students at University of Michigan, Mr. Hinkle, Mr. Clark and Mr. Mattes were selected based on their work at the Construction Information Technology Laboratory at University of Michigan. They had a strong interest and backgrounds in the research being performed here and hence were selected for this project.

This supplemental project helped to gain invaluable video and computational data. This data came from multiple views of one construction object viewed from synchronous cameras. It can serve as a test-bed to validate the current award project. Since the data is raw, other projects can also use it for validation purposes of the developed algorithm.

Aristotle University at Thessaloniki is one of the most prestigious universities in Greece. It is in northern Greece and closest to the Egnatia Odos motorway site. Pr. Angelides helped students get Visiting Scholar status at the university. The students could use facilities like libraries, relevant laboratories at Aristotle University. Pr. Angelides' laboratory served as a base laboratory for the students. Computers and other equipment in his laboratory along with that from Michigan was used for data collection. Ioannis Brilakis, assistant professor, Francisco Cordova, graduate student, Russell Hinkle, Phillip Clark and Peter Mattes, undergraduate students at University of Michigan traveled to Greece for this supplemental project from May 1st to August 31st 2008.

RESEARCH ACTIVITIES AND ACCOMPLISHMENTS OF THE INTERNATIONAL COOPERATION

With collaboration from the 2 Greek students, University of Michigan students gathered a large volume of videos (approximately 2 terabytes of videos) that will be used for the validation of the developed tracking algorithm. They used cameras that were available on site at Egnatia Odos project sites and the cameras from the CIT Lab at University of Michigan to deploy sufficiently dense camera network on the site to obtain invaluable video data from multiple synchronous cameras at several large projects of Egnatia Odos motorways like tunnels, bridges, road interchanges. They worked together with project engineers at Egnatia Odos motorway and other projects to get upto date schedules of the active sites. They used this information

to decide which activity they wanted to videotape data from on a particular day. They prepared their own schedule for the site. The students set up a mobile laboratory by attaching a table to the back of a truck. A computer was affixed to this table. The cameras were also attached to the truck. This mobile lab helped collect large quantities of data at a faster rate.

Students reported to the base laboratory at Aristotle University and assembled their equipment everyday. They would gather video data through out the day and then back it up at the base lab at the end of the day. They made sure that the equipment was cleaned on a daily basis to avoid deterioration in the video quality and also to avoid wear and tear. They helped the Greek students understand the research and provided them with the collected video data for research purposes. Figure 1 and 2 show the mobile laboratory and students gathering data respectively.

This supplemental IREE project is a part of the Automated Vision Based Tracking of Project-Related Entities project. This project aims to test the feasibility of a novel vision based technique to track project related entities in 4D (spatial coordinates and time). An important part of this tracking project is the validation process. The algorithm developed needs to be checked with real data from a heavy traffic construction site. An ideal multi-site test bed to validate the tracking methods was provided by the Egnatia Odos motorway and other projects. The tracking method developed under the current award overcame the limitation of simultaneous tracking of large quantity and variety of items for personnel, equipment and materials.

Pr. Brilakis collaborated with Pr. Demos Angelides, Chairman of School of Engineering at Aristotle University at Thessaloniki for this project. They worked together to assure access to the Egnatia Odos motorway project. They made sure that the students had badges, personal protection equipment and permission to video record at the site. US and Greek students also worked with together. US students helped the Greek students understand the research, its objectives and the impact of the current award project to the field of construction. The Greek students on the other hand helped US students with communication and language barriers. They assisted them understand the regional culture and Greek business practices.

The students collected a large volume of not only video data but also computational data (excel sheets) related to the videos during this international research. They encountered myriad problems in this transition and learnt the risk of undertaking such an endeavour. The students thus gained a significant amount of research experience. They collected data from different sites through out their stay in Greece. In May, they recorded construction at the Thessaloniki Metro project. They congregated data at the Egnatia Odos motorway sites in June and July and finally in August they videotaped construction at the Aposelenis Dam. Throughout the summer the students gathered data from different projects of varying size with heavy traffic of equipment, labor and material.



Figure 1. Mobile Laboratory set-up



Figure 2: Student gathering data

BROADER IMPACTS OF THE INTERNATIONAL COOPERATION

This project gave four US students a chance to explore the world outside US. Some of these students came from underrepresented groups. They got a chance to represent minority groups on an international level. Some of these students had not even traveled beyond the state of Michigan, let alone the US. This project exposed the students to different engineering practices followed by Greeks and construction practices outside the mid-western US.

This project helped expand the scope of the current award project. Egnatia Odos and other sites provided a large scale, diverse construction with heavy traffic, an ideal test-bed to validate the current award project. Also, this data can be used for the validation of any other research project since the data is raw. US is a developed nation and most of the infrastructure construction is already complete. The construction that takes place is aimed at maintaining the old and deteriorated highways (ASCE, 03). The US thus offered a low diversity, small scale of low traffic sites. Developing nations in the world are still in the phase of building infrastructure and highways. China, Russia, Greece are some of the developing nations that are under heavy infrastructure growth right now. During the last decade, Greece has had an infrastructure growth and economic development significantly higher than the average EU or US rates (Eurostat, 2007). Egnatia Odos motorway is a landmark project in the large-scale infrastructure projects in Greece. This project provided us with a number of active projects with tunnels, bridges, road interchanges. The variety offered by this project in terms of construction, equipment and traffic expanded the scope of the current project. This supplemental project gave access to testing the algorithm developed with the help of the current award project at a much grander scale than what the US would offer.

Visit by our research group to Aristotle University at Thessaloniki created close ties with the foreign collaborator, Pr. Angelides and his colleageaus. As promised through this collaboration, the foreign collaborator and his research group will reciprocate the visit for research on another project. Pr. Angelides showed interest to exchange scientific culture and ideas with University of Michigan in the near future.

This supplemental project gave a chance to four students at University of Michigan who had never traveled outside USA a chance to experience a different country. These students learnt to live and work in a non-English speaking country. This experience exposed them to the Greek language and culture. It helped them understand the difference between American and Greek business practices. This trip presented to them the vastness and the variety in daily conduct that can be seen in the same profession of construction. They learnt about the differences in the way construction was carried out. They observed differences in the safety practices, labor, planning, scheduling, and equipment usage in the two countries. They solved myriad problems on a day-to-day basis in an unfamiliar environment. The trip made them more mature, better leaders and problem solvers in their area of interest.

The students increased their familiarity with Greek culture, engineering and business practices by enrolling in “GREEK 101/502: Elementary Greek” and “GREEK 102/503: Elementary Greek” offered at the University of Michigan. This helped them improve their understanding of the Greek language in order to communicate with Greeks. The students undertook orientation classes offered by the International Programs in Engineering (IPE) office at University of Michigan. This helped them get familiarized with the Greek culture and identify differences with the American culture. They were exposed to Greece- US relations and to the history and geography of Greece. In Greece, they understood the business practices in Construction Management and technological trends in Greece.

DISCUSSION AND SUMMARY

Students that traveled to Greece from USA collected almost two terabytes of video data. This data is of good quality and in a raw format that can be used for any project application. These videos came from multiple synchronous cameras, which were focused on the same construction object. They can be used to test the performance of the current award project (Vision Based Tracking of Project Related Entities) and any other algorithm that involves usage of videos. The students also collected data in the form of computational files (excel spreadsheets). There are files that also give information regarding the videos.

The project sites at Egnatia Odos motorway and other projects like Thessaloniki Metro project provided a huge database to validate results. These projects were grandiose projects with a variety of construction activities. They were sites with a large amount of passage in the form of material, labor, and equipment. The large sized project provided the real life data, the ultimate test to measure the performance of the current award project or any other project that takes place in our research group.

During this period, the students could use the laboratory at Aristotle University as Thessaloniki for research purposes. While data was being collected for validation purposes, there was research progress as well. Francisco Cordova, the project leader for this supplemental project, furthered research by developing 3-D tracking of construction personnel using hard hats for personnel recognition. It was possible to immediately verify this tracking algorithm by using the videos from Egnatia Odos motorway project for validation. Another student in the research group used these videos to check the performance of the camera self-calibration algorithm. This algorithm will make it easier to track project related entities. Results from both, the 3-D tracking algorithm and the camera self-calibration algorithm had promising results.

Other significant accomplishment was the growth of the students. The students traveled out of US for the first time. They experienced being in a different country. They learnt to overcome barriers of culture, norms and language to attain their goals. They learnt to collaborate effectively and efficiently with different cultures. They led the project in an unfamiliar environment; troubleshoot myriad different problems yet produced amazing results in the research. They returned from Greece, more mature, confident and with honed leadership abilities, and professional attitude.

Challenges faced by the students were mainly related to the equipment supply. The computers and cameras being fragile instruments were subjected to wear and tear on the large open construction sites. The IREE project required a lot of equipment like wires, generators, computers, cameras, and power supply switches. However, we were not able to budget for these things in the original proposal. It would be helpful if we were able to do so.

Overall, this experience in Greece was of great significance to the advancement of the research project and the personal growth of the students that made the trip to Greece.

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BRIEF BIOGRAPHIES OF RESEARCHERS

Ioannis Brilakis received his Diploma in Civil Engineering from the University of Patras, Greece in 2001. He received his M.S. and Ph.D. degrees in Construction Management from University of Illinois at Urbana-Champaign, USA in 2002 and 2005, respectively. He joined University of Michigan, Ann Arbor as an Assistant Professor at the Department of Civil and Environmental Engineering from July 2005 to December 2008. He joined Georgia Institute of Technology as an Assistant Professor in January 2009. He is the director of the Construction Information Technology Laboratory and an active member of several academic and professional organizations.

Francisco Cordova received his Diploma in Civil Engineering from University of Puerto Rico at Mayaguez in 2007. He received his M.S. degree in Construction Management from University of Michigan, Ann Arbor in 2008. He worked as a research assistant for Dr. Brilakis from 2007-2008 working on the Automated Vision Based Tracking of Project Related Entities project.

Phillip Clark, Russell Hinkle, and Peter Mattes are Undergraduate students at University of Michigan. They are expected to graduate with BSE in Civil and Environmental Engineering in 2009, 2011, and 2009 respectively. They worked in the CIT Laboratory at University of Michigan under the direction of Dr. Brilakis.