Panoramic Augmented Reality for Persistent Information in Counterinsurgency Environments

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ABSTRACT

Modern Counter-Insurgency (COIN) and Irregular Warfare (IW) are increasingly complex. Contributing to this complexity is the need to develop and maintain a mental map of relevant environmental and historical factors and their interactions, generated from disparate sources of information that must be organized, processed and integrated. Compounding this challenge is the fact that mental pictures cannot easily be passed from one soldier to the next. This is a problem when the tactical situation dictates frequent changes in unit Areas of Operations (AOs), and particularly in cases where units rotate on a regular basis. When units hand over an AO, the incoming unit has to quickly rebuild a mental picture or "story" of their operating environment and much organizational knowledge is lost.

This paper discusses the type of information and a prototype system architecture that enables a vehicle crew commander to view, organize and to spatially input this complex operating picture, through placement of 3d interactive symbols directly into the real-life on-site scene from the vehicle perspective. A panoramic camera and dashboard monitor give the commander a surround view, a 360 degree laser range finder supplies the range information for accurate annotation geo-location. This is intended to allow greater performance by combat units in a COIN situation, through increasing situational understanding of the complex environment.

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INTRODUCTION

Success in modern combat is increasingly dependent on the flow of information. Compounding this are the circumstances found in a low-intensity combat situation, such as the counterinsurgency (COIN) we currently face in Afghanistan and Iraq. In this environment, situational understanding involving the civilian populace is key: this greatly increases the difficulty of the situation, because social-cultural knowledge is difficult to describe and communicate. For example, it is useful to know if the house a user is looking at has been searched by previous units, and what was found during the search.

This paper analyses information that can be displayed to identify the most valuable and feasible types. It also describes a system configuration for an Augmented Reality (AR) system that could aid vehicle commanders in an operational setting. The focus of this research and prototype system development is to improve situational understanding by integration of spatially related data into an indirect view of the outside environment in combat and patrol vehicles for use by vehicle commanders. Street names, building information, blue force platforms and intelligence data are fused with the video from vehicle-mounted cameras. Terrain-associated knowledge hence persists in place in the environment, rather than being verbally relayed, stored in text documents or on paper maps, or being lost entirely. Crucial information - unobtrusively displayed at the right moment and place - allows a vehicle crew to better understand their operational environment, to be aware of threats that may be present, and ultimately to improve situational awareness and crew safety.

RELATED WORK

Augmented Reality

There has been considerable research in the DoD over the past fifteen years in the AR field. Some augmented reality projects that have and/or are been fielded for research include:

- NRL's Battlefield Augmented Reality System (Livingston, et al., 2002)
- DARTS (Dean, Jaszlics, Stilson, & Sanders, 2008)
- MARCETE (Kirkley, et al., 2002)

These have been under investigation for several years, and have contributed much to AR research for DoD. However, they are intended for research, and are not yet capable of what the DoD expects of an AR system. An example of such requirements can be found in the paper "Soldier 2030" (US Army, 2009), which discusses numerous technologies, many of which incorporate AR.

Indirect Vision

As we will discuss, the idea of panoramic indirect vision may have possible uses in an AR system. One project that has investigated this is the See-Through-Turret Visualization: STTV (Belt, et al., 2000) project, which investigated placement of cameras around the turret of an M1 tank, with displays for the crew. This did not incorporate AR, but displayed the potential for this, since live video allows addition of annotations.

Existing Situational Awareness Projects

There have been several important efforts made in bringing information collaboration to the small unit leader in a counterinsurgency.

Command Post of the Future (CPOF) is a planning and tracking tool suite which has recently been fielded to company-level command posts, and features a large suite of functions for sharing and storing information.

The Tactical Ground Reporting (TIGR) system has been fielded as a web application which allows users to input data and embed multimedia sources, in order to collaborate and disseminate vital tactical information.

Challenges

From review of the related work, we conclude that the DoD currently has not fielded an in situ augmented reality system for use by combat troops. This is mostly due to the following factors:

1. AR programs tend to be found in particular "stovepipes". There are AR systems aimed

toward training, and systems intended for investigating operational use. These systems tend to not cover multiple domains. The idea of using an AR system for training execution of tasks actually conducted without an AR system is fraught with problems. Also, an AR system most likely would come with a fairly substantial cost, if fielded across the force: for a training-only system, this is probably not cost- effective.
2. The majority of DoD AR efforts are centered around a dismounted individual user. This introduces multiple complications, which are not easily solvable at this time.
3. No system has been realized which can provide an operationally useful AR capability, thus no compelling demonstrations of AR can be conducted, and no evaluation of the possible gains to be realized from the technology can be effectively conducted.

It is our hypothesis that a functionally useful, operational augmented reality system can be fielded today, if some of the historical technological and organizational pitfalls can be avoided. Our prototype Panoramic Augmented Reality for Persistence of Information in Counterinsurgency Environments (PARPICE) is intended to be a test bed for validating this hypothesis.

Technological Shortfalls in Current AR Systems

By and large, the focus in AR today is aimed at the "holy grail": a fully augmented system for dismounted personnel. The US Army's goals for such a system are summarized quite well in the "Soldier 2030" paper (US Army, 2009). Some of the features of a system include:

- A see-through Head Mounted Display (HMD), which allows a normal view of the real world, but with projected augmentations overlaid onto this view. While this technology is being developed, it is not feasible at this time, due to display quality and alignment issues
- Determination of the position and orientation of such an augmented view requires very precise and stable tracking mechanisms. Because of the properties of the human body, this is technologically quite difficult to achieve.
- The processing of tracking and rendering information in order to generate registered augmentations requires quite a powerful computer system. At this time, an adequate hardware system would manly be found in desktop computer format. This is not practical to wear on a human body in a useful manner.
- The weight of a power supply to run such a system adds to this impracticality.

The PARPICE system is intended to explore ways to minimize the negative effects of these technological challenges.

OPERATIONAL PROBLEMS TO ADDRESS

Over the course of the authors' operational experiences in Iraq, it has become apparent to them that the Soldiers and Marines in combat units at the company level and below are at a disadvantage when compared to higher units in terms of informational capabilities. While higher level command centers have great capacity in terms of networking, computing, visualization and communication infrastructure, actual units operating in the field are still fielded limited technologies such as Blue Force Tracker (BFT) / Force XXI Battle Command for Brigade and Below (FBCB2) and FM voice radio communications. While these systems are battle-tested, they are limited in their ability to unobtrusively provide a knowledge-immersive environment for the operational user in a combat situation. The main media for communication and persistence of data amongst tactical units are plain text patrol report documents, and planning diagrams are still created using Microsoft PowerPoint™, and carried on operations printed on paper. A number of systems were recently developed to enhance the capabilities of operators: However, these tools rely on physical networks, and thus are only found in use in command post-type settings. On the other hand, the warfighter on the ground, immersed in the real world of a combat theatre, has very little in the way of accessing and leveraging knowledge of his surroundings that has been accumulated over years of operations by numerous units in his particular locale, and which could be of great help in understanding his environment in a more "full-spectrum" manner. This in-situ knowledge is challenged in its sharing and dissemination in several ways:

Mental Map "Transcription"

One of the problems with reliance on standard text and image documents is the fact that the information user must first ingest the information in the correct manner, and then correctly generate a mental model or map of that information and synchronize that mental construct with the surrounding reality. This has problems in that interpretation is difficult without context, and context is difficult to generate without experience. This creates many "leaps", all of which can inject error, and which require energy and time to execute.

Persistence and Consolidation of Knowledge

Another problem with the current method of relaying information amongst succeeding units in a location is again tied to the loss of context.

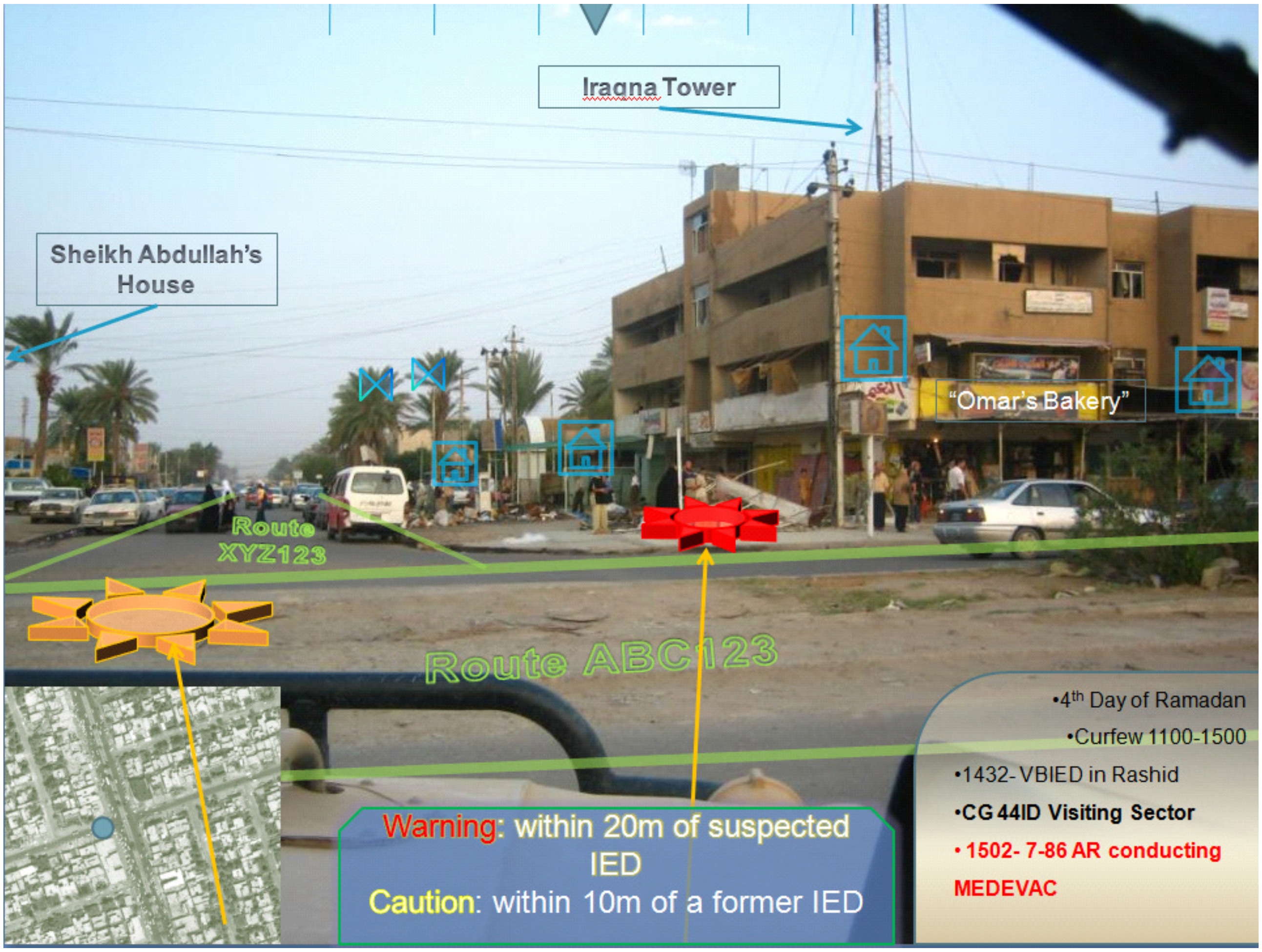

Figure 1. Objective Example View from AR System

Every time units transition (either due to deployment rotation or irregular operational area adjustments), the standard method for handover is two part: the outgoing unit briefs the incoming unit, then the two conduct operations together for the transition. The second part consists of handing the incoming unit a package documents in which resides historical knowledge of past operations involving the area of concern. While these two pieces are superior to nothing, they leave a critical portion unfilled: it is still up to the incoming unit to internalize this information and place it into context.

Due to the rotational nature of deployments, units are continuously moving in and out of theater. Adding to the confusion is the fact that, for operational reasons units frequently change areas of operations (AOs). This is problematic in a counterinsurgency because deep knowledge of the operational environment is critical to success. COIN is not conventional military activity: it involves a great deal of interaction with the populace, and understanding a great many features of the environment, including civil and religious institutions, infrastructure and essential services. This understanding comes at the price of a great deal of time spent with the populace, and an understanding of the particularities of the local environment. Units can rapidly lose track of past occurrences experienced by predecessor units: This could be helped, however, if there were immersive "cheat sheets" which could tie amplifying data about the environment to particular locations. Our research focuses on evaluating the premise that augmented reality has promise to be an efficient way of communicating spatially-tied information in this context, assuming a useable system.

AUGMENTATIONS

The data to be displayed by an AR system is of course central to the entire enterprise. The main experimental focus of this research is to determine methods for and priority of annotations that can be displayed with the most benefit to the vehicle commander and that are the most feasible with current AR and visualization technologies. As mentioned previously, filtration methods will play a primary role. If too many annotations are displayed, the scene becomes indecipherable.

There are numerous methods for filtration of visible augmentations:

- Location: only displaying augmentations tied to locations in actual view
- Layer: basing filtration on a layer data hierarchy, with augmentations located on layers based on a common attribute, selected by the user
- AI: Filtration through computer assistance, using artificial intelligence techniques
- Priority: based on previously estimated value of the impact of such a piece of information (i.e. an attack on the previous unit to use the routed taken would have higher priority than the fact that an attack had occurred in the same location several years previous).
- Time: per analysis, filtering based on time elapsed since annotation was entered; event occurred; or frequency of such an event

Our design initially aims at the first method of filtration only, for simplicity's sake: This is accomplished by spatially filtering according to the underlying model and LIDAR input.

Augmentations can have different forms, and vary in degrees of freedom based on requirements. Some information is static to the screen: this could be seen as similar to a head up display. A text field in the corner of the screen, displaying various text messages is of this sort. A second type of annotation is attached to a particular point location space but does not have spatial extent, and can include text. An icon indicating that a particular house has data associated with it is of this type. The third type of annotation has three-dimensional extent (size). Lines and polygons "clamped" to the ground or other geometry of this type: an example of this type would be a label and line "attached" to the road being travelled upon, indicating that it is a named route.

Annotation Analysis

Annotations and augmentations can take numerous forms. The following are some possible areas of application for a system incorporating AR, such as our prototype:

Spatial Representation of Blue Forces

Combat units depend on accurate knowledge of the locations of friendly forces, enemy forces, and noncombatants in order to employ weapons for maximum effectiveness while minimizing destruction of civilian infrastructure and preventing innocent loss of life. Currently, most spatial representation of forces is via a 2D overhead map view of forces, which can often be difficult to comprehend by units operating on the ground. With our proposed system, the user can mark enemy locations, view noncombatant no-fire areas, and track adjacent friendly forces from an intuitive operator viewpoint. With our proposed system, a combat leader could annotate areas on the screen where adjacent forces should move to, for example: display of a route that has been cleared through a minefield, or defilade where a truck can safely deploy attached infantry.

Figure 2. Concept: Visual ID of Friendly Aviation

Intuitive Navigation Information

Combat units must be able to navigate foreign urban and rural areas, on strict timelines, usually with incomplete maps and limited knowledge of the terrain. Our system proposes to provide an intuitive display of relevant route information, by labeling the road with route names, allowing users to enter rally point and landing zone information into the database for easy navigation in the event of emergency, and display of check point distance and direction.

IEDs

Improvised Explosive Devices (IEDs) are a major threat to the security of coalition forces and civilians in Iraq, and increasingly in Afghanistan. A characteristic of IED attacks is that there are locations that tend to be reused because they are good "spots" for attacks. Units build familiarity with their areas of operations, and tend to know and avoid such areas, or else conduct operations to secure them. However, on major transit routes, transiting units may be unfamiliar with the area and are thus more vulnerable to such attacks. This can be addressed by placing icons on a paper map or battle command system, but this has the disadvantages of lack of resolution and the additional load of mentally transitioning from the map to the view of the scene. An AR system displaying exact locations of previous IED attacks can potentially be of great benefit in avoiding these dangerous areas.

3D Building Opening Designation

Combat units have systems for "naming" openings in buildings, for rapid designation and communication of locations within the building. Another intended function of our proposed system is allowing the user to "tag" windows, doors, etc, with 3d labels, and share that throughout the unit for synchronization and easy correspondence.

3D Model Generation for Turnover and Mission Rehearsal

With the integrated spherical camera and LIDAR of our suggested system, combat units could produce accurate 3D models of their operational area, thereby enabling units prior to a mission to investigate fire geometries for maximum effect, damage radii from indirect fire and aircraft ordinance (to include the possibility of collateral damage), areas to deploy troops for maximum cover and concealment, reserve force locations and landing zone selection. This accurate 3D model can then be provided to the relieving unit for mission training and rehearsal even before arriving in theater. In addition, 3D models have been investigated for use in vision-based navigation (Reitmayr & Drummond, 2006), which has the benefit of not requiring an external signal for obtaining position information.

Supporting Arms Integration

Combat units depend on rapid response for casualty evacuation (CASEVAC), deployment of Quick Reaction Forces in the event of needed reinforcements, and responsive fire support from ground and air based platforms. Calculation of the target grid, direction, distance and elevation data from a 2D map needed for these services can often be taxing on a combat leader under enemy fire. Our system proposes to address these issues by allowing the combat leader to select a point on the screen and derive all relevant data needed to call in a needed fire mission or other service.

Table 1. Example Elements of Information for Display, and Initial Evaluation Metrics

Elements of Information/ Knowledge	Metrics for Situational Information				
	Spatial Dimensions	**Timeliness/ Duration**	**Criticality**	**Precision**	**Mode of Presentation**
Locations of Blue Forces	Point	Update < 5 Seconds	High	High	3D Icons (Unit Symbols, etc)
Attack Locations (IEDs, Sniper)	Point or Area	More Recent = More Frequent	Extremely High	Very High	3D Icon(s)
Route Information	Linear	Enduring (duration of ops)	Medium	High	3D Lines registered to the road
Person of Interest	Multiple Points (locations tied to personality)	Perishable: people move, and affinity changes	Medium	Low	Attachments to 3D Icons (hyperlinks to external text box)
Culvert Locations (under roads)	Points	Enduring (dependent on change in status: filled in, etc.)	Medium	High	Lines / Highlighted areas
Host-Nation Government Locations	Points	Update < 1 hour if possible	High	Medium	Similar to BLUFOR
Cleared CASEVAC Helicopter Landing Zones	Area	Update daily, if HLZ has been passed by patrol	High	High	Highlighted area

Table 1 on the previous page is the summary result of our analysis into the usefulness and feasibility of visualization of various example types (elements) of information. An early operational AR system should focus on visualizing data that can is spatially well localized (as opposed to a larger area), that is of high value to the vehicle commander, that is difficult to make available on paper or other media, that does not require very frequent updates and something else. For that reason, we suggest that the items in Table 1 that have both high criticality and precision requirements are most applicable to being dealt with by our system.

SYSTEM ARCHITECTURE

The overarching goal of the PARPICE system is to be able to generate an augmented view of an urban environment for a tactical leader that allows interaction with spatially registered symbols and associated information. An example of such a view can be seen in Figure 1. The PARPICE prototype system can be decomposed into six main functional groups:

- Mobility & Support
- Sensory Throughput
- Environmental Sensing / Modeling
- User Interface
- Pose determination
- Augmentation Generation

Descriptions of these functions and associated subsystems are as follows:

Mobility and Support

Due to the aforementioned difficulties presented by the current form factor and power requirements of a realistic AR system, we chose to not attempt to create a dismounted personal system. Rather, we instead chose to base our system on a vehicle platform. This was possible due to a truck that was on hand from previous thesis research at NPS. (Haines & McFerron, 2006)

This is operationally realistic (particularly in urban operations in Iraq), because almost every combat unit in that theater possesses at least up-armored M1114/M1151 HMMWVs or Mine Resistant Ambush Protected (MRAP) vehicles, and most of them use these vehicles for patrol operations. The vehicle platform has the following advantages:

- Weight capacity: a vehicle platform allows the system to be much less impacted by weight restraints.
- Power: power/battery limitations and issues are much reduced by basing the system on a vehicle.
- Stability: the relative rigidity of a vehicle creates a much more stable platform for our system. This has great advantages in determination of the overall pose (position and orientation) and predictability of the view: vehicles tend to be limited to fewer degrees of freedom of movement than do humans. Vehicles, for instance, generally cannot leap side to side.

Figure 3. PARPICE Vehicle

Sensory (Visual) Throughput

Because of the very nature of AR, we require a means of viewing the external world. In a vehicle, this could be accomplished through different methods.

Display Possibilities

The first method for the display portion of this function would be to utilize a “head up display” or HUD, to view the world and augmentations by looking through some sort of optical combiner. This has the advantage of providing a much higher resolution view of the external world, due to the superior resolution of the naked eye compared to technical devices at the current time. However, this has disadvantages as well. A HUD-type display is limited in field of view: unless we can enlarge the typical HUD to enormous size, the augmented view from our vehicle will be quite narrow. This is acceptable in a combat aircraft, because a fighter pilot’s interaction with the external world generally involves shooting, and fighter aircraft tend to be pointing at targets they are shooting at! This is not the case when we are interacting with the surrounding environment in a counterinsurgency campaign in an Iraqi town.

Also, even if we were to enlarge a HUD to cover the entire view through windshield, our view would still be limited to seeing through the windshield. Combat vehicles tend to be armored for the sake of their occupants, and thus visibility tends to be poor. In a HMMWV, for example, visibility is essentially limited to approximately an 80° arc to the front of the vehicle, with the exception of some small areas near to the sides of the vehicle. Incidentally, because of this fact, HMMWV crews heavily utilize the machine gunner positioned in the turret atop the vehicle for visibility purposes. This position is by far the most vulnerable on the vehicle, and many gunners become casualties to rollovers and sniper fire.

Another option for seeing the external world from the vehicle would in fact be a HMD similar to that used in a dismounted application. This could be implemented in three major ways:

- Utilizing the optical see-through (OST) method, we could track the head of the user and display appropriate augmentations. This is not optimal, since we still bump up against the aforementioned lack of visibility from the interior of the vehicle. Augmentations could be easily displayed: however, if looking to the sides or rear, the user would see near-meaningless symbols overlaid onto the inside of the doors, seats, floor or ceiling of the vehicle.
- Utilizing a video see-through (VST) method, we could mount cameras on the front of an HMD containing two video displays, and augment the video stream which is displayed to the user. This has the benefit of fixing the viewpoint of the user to the view of the cameras, which helps with the alignment of augmentations to the view. However, this is outweighed by several complications
    - The resolution quality of current video technology is greatly inferior to the human eye. This means that the user's view would be degraded to an unacceptable degree
    - Electronics have a disturbing tendency to break. This could be dangerous in a combat situation, where the user could quickly find himself completely in the dark upon system failure. This is generally not favorable.
    - This method suffers from most of the disadvantages of the previously described OST method, since we are still looking at the interior of the vehicle
- Utilizing a similar VST method, we could instead use externally mounted cameras, and view the outside without the bother of trying to look through armor plate. This could be an improvement, but the user then could find it difficult to see those things on the interior of the vehicle that are of actual use. We additionally still suffer from the failure problem. (This method of indirect vision has been tried in the Army's See Through Turret project)

The third (and our preferred) method is as follows: we make use of cameras mounted on the exterior of the vehicle, to provide an unobstructed view of the world. However, instead of a HUD or HMD, we introduce the idea of using a simple flat panel display in front of the user, as seen in Figure 4.

Figure 4. User Display Mounted in PARPICE

This has many advantages, in that it doesn't significantly obstruct the real world view through the windshield, so conventional vehicle commander tasks are not impacted. And it won't block the user's view in case of a failure.

There are limitations to this method: particularly the degraded resolution of the view due to the video technology. However, this is not too significant because we are using the video for placement of and interaction with 3d augmentations, and not for long distance vision.

Video Camera

On the other end of the visual throughput subsystem; because of our choice of display, an externally mounted video camera system must be configured. Our choice for implementation of this system is the Ladybug 2 spherical camera from Point Grey Research (see figure 5).

Figure 5 (Left). Ladybug 2 Camera
Figure 6 (Right). Velodyne HDL-64E

This is an array of six cameras arranged to cover most of a 360° spherical panoramic view. These produce video streams which are composited and stitched to produce an "unwrapped" spherical-frame video stream. The camera is mounted on the top of the vehicle, to allow the maximum field of view of the surroundings.

Figure 7. Panoramic Video Frame from Ladybug

Regardless of the possibility of augmenting the video stream produced by this camera, in itself it is of use. We can not only view the surroundings of the vehicle, but record this video as well, for after action review purposes, or for static use in a Google StreetView™-type application.

Environmental Sensing / Modeling

In order to construct a useful AR system, it is helpful to have a means of understanding the 3D structure of the surroundings. Placing augmentations accurately while viewing the world through a flat screen requires us to have an understanding of the depth of objects seen on the screen, which a flat image does not provide.

One way to obtain this depth/distance information is to track our position within a virtual 3D model. This allows us to lookup objects by shooting an intersector ray from the camera viewpoint to the model, then retrieving the intersection point and object information. Because of our current wealth of collection systems, we have access to light detection and ranging (LIDAR), via the Army's Topographic Engineering Center http://tec.army.mil,. (In this case, unclassified data: see Figure 9).

This data can be used to rapidly generate a 3D terrain model for use to use in our system. This can be useful, assuming we have accurate and precise positioning data for our vehicle, and have up-to-date data for generating the model. However, there are difficulties with both of these requirements.

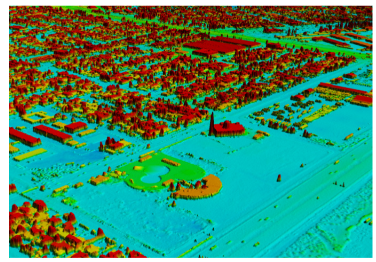

Figure 8. 3D Model from TEC LIDAR Data

A second way to obtain depth/distance information which is less affected by these difficulties is to use a live scanner to intake the depth of the scene, and then use that to get positioning data for the augmentations. In our system, we use this approach, by incorporating a Velodyne LIDAR scanner onboard the vehicle.

This sensor is commonly used in robotics applications to generate maps of surroundings. (See Figure 9) It contains 64 laser rangefinders, and operates by spinning at 10hz, collecting approximately 130,000 3D points per revolution. In turn, in these robotics applications the map thus generated can be used to extract the location of the scanner. This is known a Simultaneous Localization and Mapping (SLAM), and we hope to apply this technique to our human-in-the-loop system.

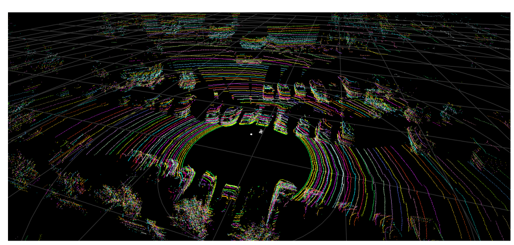

Figure 9: Raw Velodyne point data

For purposes of scene depth, however, we merely use the desired augmentation location in the video screen to lookup a depth value in a depth map generated from the LIDAR data. This has the benefit of always being updated since it is live, and the need for a pre-existing model environment is minimized.

Figure 10: LIDAR point data rendered in OpenSceneGraph

Pose determination

Accurately determining the view position and orientation is very important to the overall performance of this system, and good performance is difficult to achieve. Because there is research to be done in this field, we have chosen for simplicity's sake to utilize components already available to us, which are a handheld GPS and an inertial measurement unit (IMU), with the GPS providing location, and the IMU providing orientation.

User Interface

Interaction with an AR system requires some considerations. If using a spherical camera, we can view the entire panoramic field of view at once, or else pan and elevate a smaller field of regard culled out of the larger scene. To accomplish the latter, we can either control the view with some sort of manual input, like a joystick, or else by some other unobtrusive means. We have implemented a head tracking method using a TrackIR head tracking system (see figure 11) from NaturalPoint. This tracker calculates head pose from the positions of three reflective markers attached to a baseball cap, and provides tracking for up to 6 degrees of freedom. Because we intend to view from the spherical camera's perspective, only heading and attitude changes of the view are needed: using the TrackIR software, we can nullify all extraneous degrees of freedom. This has the additional benefit of removing much of the tracking jitter while in a moving vehicle, since translations (i.e. "bumps") and roll of the head can be ignored. The TrackIR software allows the user to keep his eyes on the display, while making mild movements of the head that are amplified so that a slight turn of the head can slew the view 180 degrees to the rear of the vehicle. The software also allows profiles for the axes to be customized to adjust acceleration levels and create "dead zones" for smoother tracking.

Figure 11. TrackIR and Hat with Markers

This head tracking method allows us to use a fixed display, while controlling the view with the head and leaving the hands free for interaction with the screen. Detailed user interaction is accomplished via a touch screen incorporated into the display, which allows standard mouse interaction methods with GUI elements and augmentations.

EVALUATION

Upon completion, we plan to conduct the following user studies to evaluate effectiveness of vehicle-mounted AR.

- Test ease and precision of placement of annotations onto real-world objects, compared with top-down navigation & battle command systems, as well as with paper maps
- Evaluate the possible gain in performance in identifying events and objects in the vehicle surroundings using spherical AR video, vs. normal methods (i.e. vehicle windows).
- Evaluate user opinions and ease of use provided by varying forms of 3D augmentations.

SUMMARY

We have outlined an intended use and architecture for the PARPICE prototype. The basic aim for this system is to enable a vehicle crew commander have greater situational understanding of his environment, and to test out AR and associated technologies to enhance vehicle crew performance, with an aim of implementing operational augmented reality technology in quick and useful manner.

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