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Thesis

Personal Virtual Assistant

Evolution of traditional office tasks through multipurpose assistant
which takes care of important office work through live and online
interactions with users

by

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Abstract

The Personal Virtual Assistant (PVA) is an innovative, inexpensive, and reliable virtual secretary. This user-friendly system will perform many of the tasks commonly performed by a traditional secretary. The PVA will eradicate such problems and it will be easy to train by updating the software. The foundation for this project has come from research previously conducted in computer vision. Advanced features of the PVA will include the ability to identify humans. Some of the problems associated with working with humans can range from forgetting to write an appointment to missing work on a regular basis. The PVA project will expand upon computer vision research and incorporate new features which will lead to an interactive virtual assistant. The system will offer communication and other solutions to users. This system can be implemented in various fields. For example, in education, it can be used to organize and ease student appointments with deans or chairs. In business, offices can use it instead of a regular secretary. This assistant will never forget about the meeting and will never be tired. Those are only the basic features of the PVA. At the long term a global network of PVA's can be created allowing them to communicate between each other without need for appearance in person.



Table of Contents

ABSTRACT	2
LIST OF FIGURES	5
INTRODUCTION	6
METHODS	8
Main Office Tasks	8
Top Level Diagram of the PVA	12
PVA Modules Diagram	13
Video Conference Module	13
User Identification Module	14
Real Time Calendar	15
RESULTS	16
User Desktop	20
1. Header Bar	20
2. Quick Announcements Bar	20
3. Main section panel	21
4. Super User Panel	25
6. Footer Bar	26
GUI Considerations	26
Help Components	28
CONCLUSIONS	30
ACKNOWLEDGEMENTS	31
REFERENCES	32



APPENDICES	33
Appendix A – Review of Computer Vision Literature	33
“Face Detection in Color Images”,	33
“Human Face Detection Using Geometric Triangle Relationship”,	34
“Face Detection and Synthesis Using Markov Random Field Models”,	36
Appendix B – Main User Identification System Algorithms	37
User Detection Algorithm	37
User Identification Algorithm	38
User Greeting Algorithm	39
Appendix C – Data Flow Diagrams	40



List of Figures

#	Picture	Description	Page
1	Picture 2.1	Top Level Diagram of the PVA	Page 12
2	Diagram 2.2	Personal Virtual Assistant Modules	Page 13
3	Picture 3.1	Welcome Screen	Page 16
4	Picture 3.2	Login Screen	Page 17
5	Picture 3.3	User Registration Screen	Page 18
6	Picture 3.4	Invalid Input User Registration Screen	Page 19
7	Picture 3.5	Valid Input User Registration Screen	Page 19
8	Picture 3.6	User Desktop	Page 20
9	Picture 3.7	Calendar	Page 21
10	Picture 3.8	Time Recorder	Page 22
12	Picture 3.9	Digital Library	Page 22
13	Picture 3.10	Quick Memo	Page 23
14	Picture 3.11	Games	Page 24
16	Picture 3.13	E-mail Center	Page 24
17	Picture 3.14	Video Conference	Page 25
18	Picture 3.15	Super User Desktop	Page 26
23	Picture 3.16	Virtual Agent	Page 28
24	Picture 3.17	Virtual Keyboard	Page 29



Introduction

The idea behind the Personal Virtual Assistant is creation of an inexpensive, reliable and easy to use assistant. PVA includes a digital camera and a Table PC with a touch-screen display. PVA can be mounted on the door of the person whom it serves. The assistant identifies the user using the User Identification System (UIS) and then assists him with a variety of possible solutions.

Such solutions include easy access to the supervisor's schedule with the option of adding or deleting a meeting using an easy and friendly user interface. The visitor sees right away all the available slots for possible appointments time and is able to add him to the list. The supervisor can see all the appointments with important details such as visitor's picture, history of previous meetings with this person, and a short description of current and past meetings. The schedule is available online as well. All parties involved in the scheduled meeting have the ability to cancel a meeting. The cancellation of a meeting automatically updates the schedule, and sends e-mail to all involved that the meeting was canceled. All involved will have access to options that allow them to be notified of upcoming meetings via e-mail.

Another important task that PVA includes is based on videoconference module. If the supervisor is out of the office, but is available for a videoconference meeting, such arrangements can be made through the PVA. The most challenging part of the PVA is the User Identification module which will identify user by digital picture pattern comparison.

Identification of a person by image processing and computer vision has always been a very challenging task. This is a difficult problem because it requires implementation of several complex mathematical algorithms of an advanced level. The probability of identification should be high enough to eliminate all possible mistakes.

In our research we provide the ability for basic comparison of content based images with the ability for farther integration of various technologies. We are trying to take the Human Computer Interaction (HCI) to the next level. The main goal of this project is to make our system friendlier than others, but at the same time to be as reliable as possible. We want to create a friendly system which will identify users without invasion to their privacy and without any direct input from them. The visitor is not required to perform any action. In similar systems the user is required to perform some action in order to be identified, such as enter a username, punch code, slide card or a similar identifying password. The user does not have to worry about remembering a card or password because the PVA will not need identification card in order to function. This advanced feature will work due to complex hardware and software interaction. This makes the HCI both more enjoyable and easier to use.



Identification of a visitor, which takes only a couple of seconds, in practice, involves very long series of actions and computer operations. First of all the system needs to detect that there is a visitor. As soon as it reaches relevant position, the camera takes pictures of the user.

User identification is done by a digital picture processing. There are a lot of important challenging issues that have to be solved. Not every one has the same height and some pictures may result in an image of only hair or only the neck of the visitor. Also, in the perfect case when the picture will have exactly users face the comparison task isn't easy at all. The person might have blinked which resulted in a closed eyes or he could have grown a mustache. All those "small" details highly increase the difficulty of image comparison.



Methods

For most successful professionals everyday business life is already extremely busy. There is no need to overload your schedule with unnecessary trivial daily tasks that do not require your expertise. Supervisors try to pass on all the tasks that they aren't required to perform personally to their administrators or someone else so that they will have more time to concentrate on the more important things. PVA can free this load from you as well as from your administrative staff leaving more time to perform your main goals and not all the surrounding necessary tasks. Small businesses as well as sole businessman usually don't have extra money to invest into hiring a management staff or their assistants. In the same time there is often no extra room and resources for such personnel, but the work exist and require someone to do it.

In our age of globalization it's very important that offices will have a reliable communication and real time information exchange. PVA targets enabling communication between several devices that will form a network of PVA's of the same office or the same company. The era of internet and mobile technologies also requires that the access to particular service can be allowed from various places and use shouldn't be tied to one location to get what he needs. PVA is a portable device which you can easily move from place to place on the back seat of your car or in your suitcase. It doesn't require addition set up on the new location except for the internet connection and power supply.

Every organization or institution needs administrative and office staff that have to perform different tasks effectively and efficiently. Even though different offices have different tasks there are main duties that are commonly shared by all of them. The staff is usually being supervised by managers who plan the work of their staff and choose their duties. In this paper the research was done in order to find out what are the main tasks and duties that office staff members have to perform. After identifying those duties we have chosen tasks that are most important and in the same time can be performed by a PVA. We created a prototype that includes an important basis for the PVA. With an improved version of PVA, you get the benefits of an experienced, qualified professional without the burden and worry of employee benefits, payroll taxes, additional office space, rent, furniture, equipment, and human resource issues.

Main Office Tasks

After the research we came up with the main basic functions that are common to many offices. Those tasks are important in the everyday work performance and are performed by a regular office assistant:

- E-mail review, sorting and response
- Typewriter for the messages that are dictated



- Preparation of labels, lists, addresses
- Operation with variety of commonly used office forms and logs
- Desktop Publishing: Newsletters, Brochures, Business Cards, Fliers, Posters, Menus, Announcements, Invitations, Post Cards.
- Word Processing : Letters and Envelopes, Forms, Contracts, Reports, Meeting Minutes, Mailing Lists
- General Office Support: Send/Receive Faxes, Monitor voice mail
- Web Site Services: Web Site Creation, Web Site Maintenance, Updates, Search Engine Submittal
- Data Bases/Data Entry: Creation and Management, Mailing Lists, Customer Lists, Data Entry, Spreadsheets, Reports
- Time Management: Employee time log recorder, Scheduling and Appointment Management , Event Reminders and Gift Service, Appointment Reminder Service
- Event Management: Invitation and RSVP Management, Sending holiday, birthday, greetings cards.
- Accounting and Financial : On-line Bill Paying

All of the services that were listed can be performed programmatically by a smart system:

Program can review e-mail and sort it based on the sender's name/e-mail or the topic of the e-mail. The program can identify special keywords in the e-mail and based on it put the letter to an appropriate category (folder). Such approach can be used for a SPAM (Unsolicited "junk" e-mail sent to large numbers of people to promote products or services) filter where program will forward e-mails that contain combination of the blocked words to the junk or trash folder. Also it's relatively easy to check validation of the sender's email. The program will review sender's e-mail address against recipients address book (safe list) and trust those e-mails as important. Every time when the system receives e-mail from the address that is new to the system it generates automatic response such as "Thank you. Your e-mail was received by the recipient". If the e-mail address is not a real e-mail, the message will bounce back and the system will add this address to a SPAM list and next time when there will be an e-mail from this address it will be deleted. The system can also respond to different predefined people. In case that the user haven't checked his e-mail for more than couple of days it can respond with a message that user currently has no access to his e-mail and can be reached by the following number. Typewriter can be created programmatically using the voice recognition data entry. In recent years the process of voice recognition improved significantly. You can speak to the microphone and it will be recorded as a text. Later on it's possible to correct this text and make improvements and additions. Computer can aid in preparation of different labels, addresses or letterheads that can be used later on envelop and letters. Program can design labels for every address entry and send required group of labels to printer.



Computer can help with the operation on variety of commonly used office forms and logs as well as desktop publishing of newsletters, brochures, business cards, fliers, posters, announcements, Invitations, post cards. Software can assist in general office support tasks such as sending and receiving faxes, monitoring voice mail. Voice recognition can be used to translate voice mail to text and this text can be sent as a text message or e-mail to a recipient. In the field of web site services: web site creation can be created through various content management systems that can receive their input in the form of regular written notes. Those notes can be scanned, translated to text and applied to predefined templates. Process of maintenance and update can be performed by a script that generates updated information. The same program can also easily submit the information about the website to a various search engines. Data bases/data entry including creation and management, mailing lists, customer lists, spreadsheets, and reports all those can be created programmatically. Time Management: Employee time log recorder, Scheduling and Appointment Management, Event Reminders and Gift Service, Appointment Reminder Service Various event management tasks can be performed through computer. Those events can be invitation and RSVP management, sending holiday cards, birthday invitations, and greetings cards sending. Accounting tasks such as on-line bill payment can be performed programmatically as well. Program can keep track on all the online purchases and at the end of the month log in to the online banking web site using user name and password of the program's owner and perform transaction to the credit company.

In addition to all the pre defined actions in the system it can "learn", and based on the input change default options. For example if someone does action "A" every week and one week he/she passed over it the system will remind and inquire user forgot it or just didn't plarto do it . In addition, PVA combines many stand alone operations into one combined infrastructure that allows data sharing between different tasks and collaboration between different operations. In addition to being a significant time saver PVA offers various new features that were unavailable before the development of the system. In addition to all those tasks PVA can have the following features:

- Digital Library of electronic books
- Variety of commonly used office forms and Logs having which you can simplify your everyday tasks. PVA will include Form Manager with main forms in PDF format that will be easy to fill and stored electronically as well as can be easily printed. Basic forms that will be included:
 - a. Inventory Log.
 - b. Mail Log that helps to keep track of mail sent and received.
 - c. The Office Supply Request Sheet and the Office Inventory Log to track all business' expendable assets.
 - d. The Accounts Payable Log as a bookkeeper that monitors the accounts payable.
 - e. The Accounts Receivable Log for invoiced receivables.

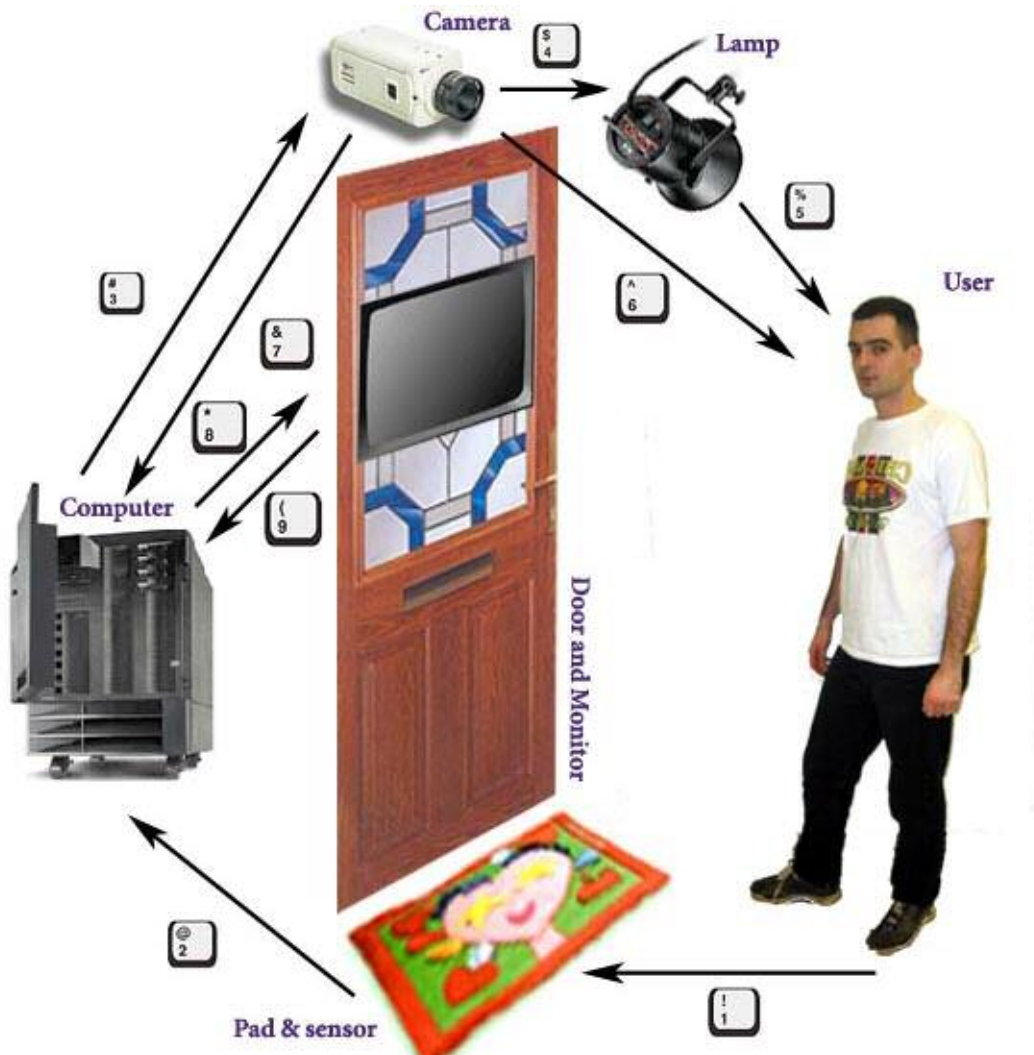


- f. Shipping/Receiving Log for parcels tracking.
- g. The Employee Information Form helps to track and record all the vital workers information.
- h. The I-9 Form records the citizenship status of new employees.
- i. The Weekly Employee and Employee Vacation Schedule helps to figure out work schedules to keep an office covered .
- j. The Petty Cash Register for petty cash traffic.
- k. The Invoice and Service Invoice forms help to track and bill for goods or services.
- l. Purchase Order form
- m. Make your fax interaction with you customers and clients clean and consistent with our professionally designed Fax Transmission Sheet.
- E-mail Center Processes incoming correspondence to determine what the subject is and decide the importance of the incoming e-mail. Several techniques will be used to do so: Looking for particular senders, particular text in the e-mail, check for spam words and SPAM senders. Generate basic statistical data regarding the incoming mail so that this information can be used later on for improvement of the SPAM filter or tasks that are performed with the e-mail. Auto responder will send customized responses to various senders based on the e-mail content and the options set by user.
- Printer status monitoring. PVA will send a test page with one word to all the printers on a daily basis and monitor the status of printers. In case of the error determine what an error number was and notify the technician on the error status.
- Additional customized modules can be added to PVA upon the need of a particular environment.

Using PVA is a wise money-saving move. Just some of the advantages are: No extra office space or rental expenses, no need to purchase additional furniture, supplies or expensive computer equipment no employee expenses, interviewing, hiring or training; the "real" cost of an employee can run 2 to 2-1/2 times their salary factoring in payroll costs such as employee related taxes, worker's compensation costs or company paid benefits, like 401Ks, health insurance, paid sick days, holidays, vacation days.



Top Level Diagram of the PVA



Picture 2.1 - Top Level Diagram of the PVA

This is a simple first-level diagram of the Personal Virtual assistant. There components of the diagram are: User, Movement Sensor, Video Camera, and a Touch screen monitor with a PC on the back-end. First of all system detect if there is a user (1). As soon as user is detected this triggers the system (2) and his height is being measured. After height measurement the camera is being moved to the appropriate height and it takes several pictures of the user (6). This information is sent to the CPU (7) for processing*. When the user is identified it sends feedback to the touch-screen (8) which is being used as an input device (9) for the rest of the interaction with the system.

* Current prototype includes a static camera without height detection



PVA Modules Diagram

The system includes several modules that interact together. Division to modules will help us see clearer structure of each project's part. In addition, modules allow reusability in different projects.

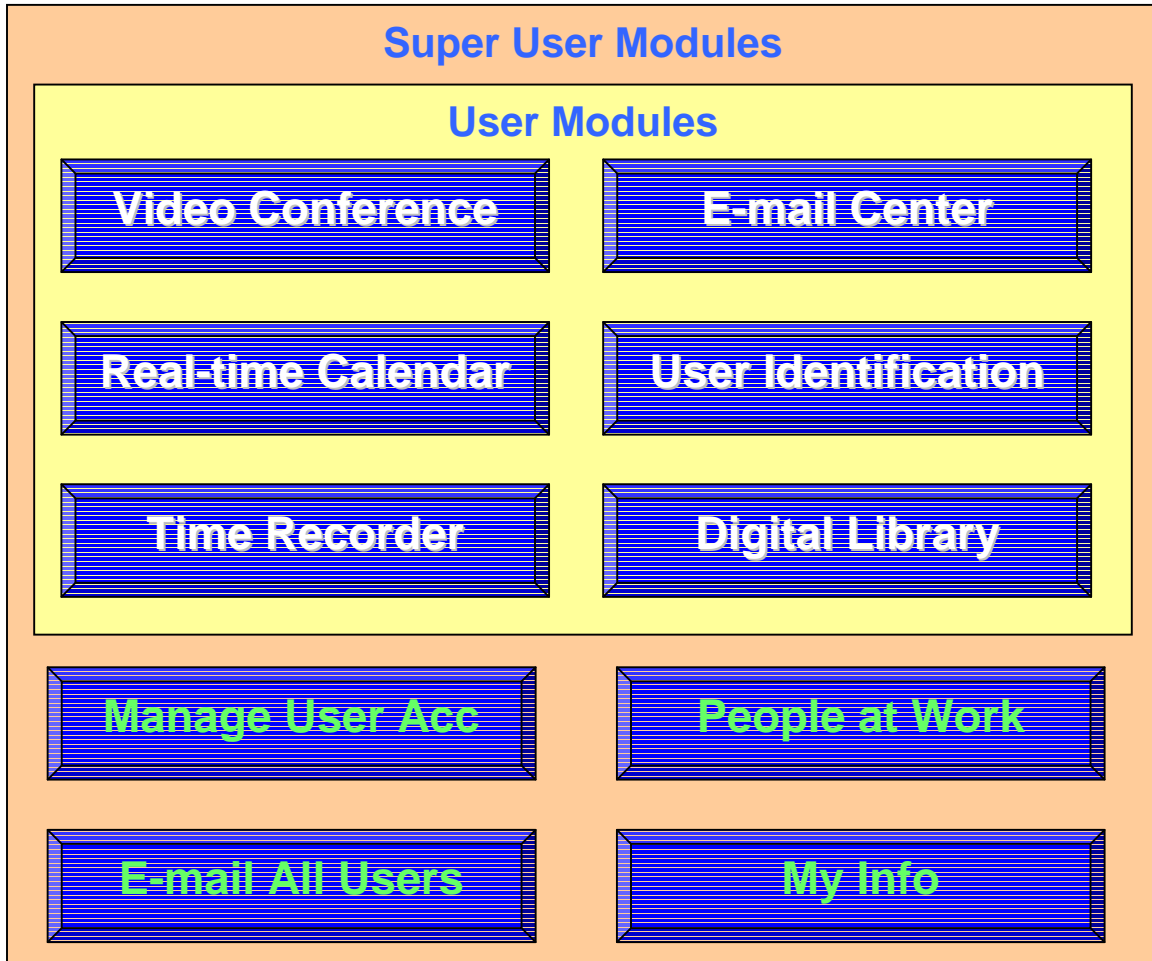


Diagram 2.2 – Personal Virtual Assistant Modules

Video Conference Module

The rapid increase of Internet speed and telecommunications need lately caused a need in finding more efficient way of communication between people. Proliferation of the number of users caused the need for an expansion of connection bandwidth as well as the deployment of solutions to eliminate noise caused by a long distance data transfer. The goal is to create a flexible client based videoconferencing over the internet using open source OpenH.323 protocol. The main objectives of this module are:

- Supervisor's availability check
- Network Status Check



- Connection Establishment
- Conference History Creation
- Support connection for up to two additional conference participants

User Identification Module

User Identification System module will have the following steps:

- User detection. This is done when there is some activity on the PVA screen.
- Getting an Image of the person. Camera gets six images of the user and best three pictures are chosen for the future work. Criteria for the best pictures are: Opened eyes (check every image for the amount of white in the eye's area), most centered image, least rotated face, meaning that face looks straight forward. When the user comes for the first time the camera collects three images and pictures are added to the database. Second time when three pictures will be collected and after identification added to a database. Third time three pictures will be collected and added to database. On the fourth visit three pictures will be added instead of the pictures collected on the first visit, meaning that the maximum amount of pictures for every person will be nine.
- Improving the image
 - Enhance the contrast
 - Enhance the intensity (brighten or darken the image)
 - Move the face to center and crop
 - Zoom in the image to fit the standard dimensions
 - Manual edit. (UIS allows manual edition of the pictures in the database. This is optional)
- Comparing images. This is the most challenging part of the system. We need to compare images, detect similarity and decide whether this is enough for the statement that those pictures are of the same individual. Here is the list of some of the basic techniques that will be used for the purpose of comparison. The most important is the last section which will combine various comparison algorithms.
 - Face edge detection
 - Face proportion detection
 - Eyes comparison
 - Identification of eye brows and comparison by width and length
 - Detection of mouth and identification of it's length
 - Eye-nose relativity
 - Nose detection and height measurement
 - Side shape of ear comparison.
 - Advanced mathematical matching algorithms. This is the most accurate part of image comparison. Algorithms will include matrix comparison of both images using the number values for brightness of every pixel of the image.



Real Time Calendar

This module will have the following objectives:

- Add meeting. This option can be done both by a supervisor and a visitor.
- Cancel meeting. Current option can be done both by supervisor and visitor. As soon as this information will be updated the appropriate e-mail message will be sent both to visitor and supervisor.
- View Log of meetings. Every meeting will create a log with all the relevant details of the meeting.
- Additional features such as friendly and easy to understand interface, every user has his picture (from database), every user has a history of previous meetings

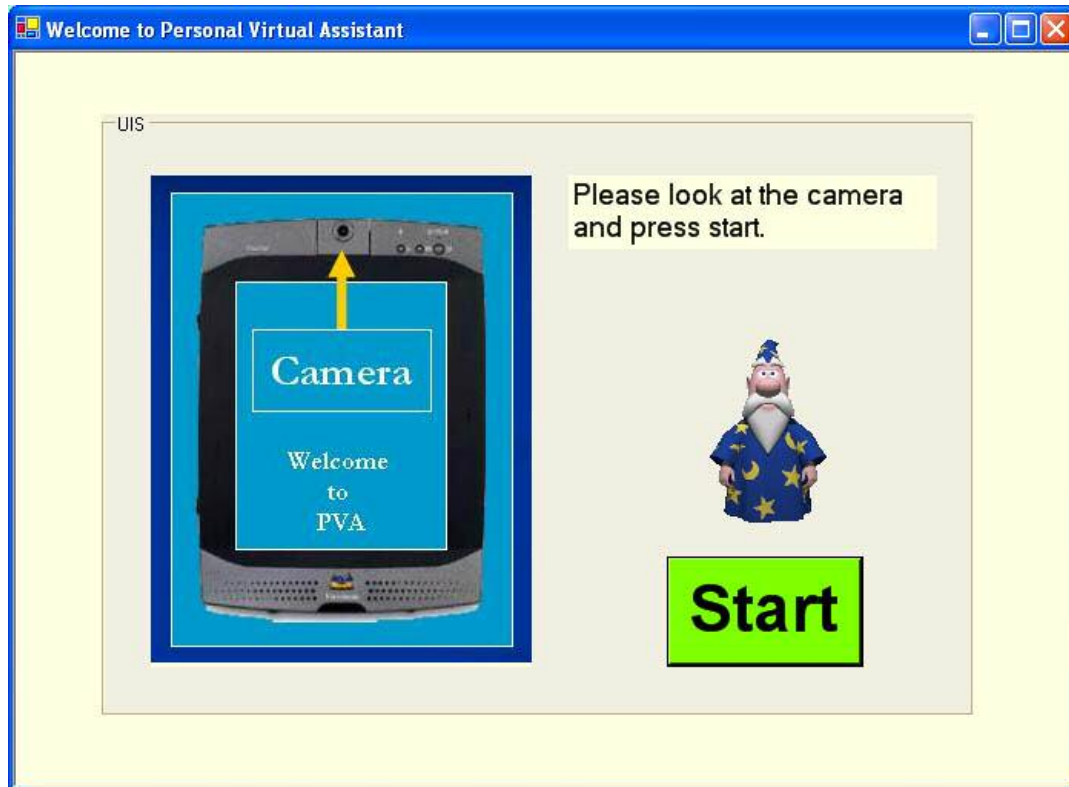
PVA highly optimizes the time that is being spent on various conventional tasks. Prototype of the system was successfully tested in the CSIS department of the Pace University and compared to the statistical information that was gathered from performance of the similar tasks in the same department. The following outstanding results were received. There was a significant decrease in the amount of time that was required for tasks performance and a very low learning curve for the use in the system. Let us review the differences in operations length for the following tasks: Recording time in time sheets, setting up an appointment, getting a book, and leaving a quick memo for the supervisor.

In addition to existent tasks that are in deveopement we also leave a very important room to feedback from customers. We believe that feedback is one of the essential steps on the product improvement path. In addition to that PVA can be also customized to the needs of the particular firm. Additional modules can be developed and easily added to the existent framework so that particular company will be able to enjoy from specific company related tasks. The assortment of PVA services creates a one-stop shopping for all the administrative needs of particular business. In summary PVA increases productivity, save time and reduce money waste.



Results

Let us review the structure of the PVA in a sequential way similar to user's interaction with the system. When a user arrives to the system the system is being in a waiting state. There is a Welcome Screen being displayed with a 'start' button.



Picture 3.1 - Welcome Screen

Once the start button is pressed the system turns on from the waiting mode and performs visual user identification. This is done by a built in camera which takes several snapshots of the visitor and compares them with the images that are saved in the user's database. The system uses algorithm with various pattern matching techniques. This is a very difficult and complicated procedure. PVA has an under development prototype of the visual user detection that identifies and compares basic shapes such as circles, rectangles and etc. The purpose of the shapes comparison is to show that it's achievable having visual user identification. With an improvement of the identification algorithm it would be possible to identify various people's faces and increase identification accuracy.

Improvement of the visual user detection algorithm can be done by implementation of the following as well as additional techniques. Matrix Comparison - Every image is transformed to the black and white. The image is transformed into the matrix of numbers. Every number represents the darkness of small pattern of the image. (White is 0, black is 100). Then image is centered



and zoomed so it will have the same dimensions as every other image. After this image is compared to the second image and if they don't match, the image is slightly rotated along x and/or Y axis with constant comparison to the most similar images in the database. Eyes and Eyebrows Comparison - Detection of eye and identification of the eye color, width and length of eyebrows. Mouth - Detection of mouth and identification of the length of the mouth. Eye Nose Relativity - Detection of relative distance from center of eye to nose holes. Nose - Height of nose.

In case that the virtual user identification was successful and the user was identified, the system logs user into the User Desktop. In case that the user was not identified by the system or in case that the user had never used the system before and his image is not on file, he/she will be automatically redirected to the Login Screen.



Picture 3.2 - Login Screen

The Login Screen will allow the user to enter his username and password or in case that the user forgot his password it will allow to get the password by e-mail. If the user doesn't have an account with the system, it's possible to get one by clicking on a 'New User' button.



Registration

Please enter your information.

User's Data

Username

Password

Verify

First Name

Last Name

E-mail

Register Clear All Help

Picture 3.3 - User Registration Screen

When this button is clicked a 'User Registration' screen appears. This screen collects basic information about the user such as: username, password, first name, last name and an e-mail address. All the information is being verified for correctness. The following user input validation checks are being performed: username can't match any of the usernames that are already registered in the system, first name and last name can't be shorter than two letters, password should be at least four digits and shouldn't differ from password verification, and e-mail should be in a valid e-mail format. If some or all of the users input is not valid the system will display an appropriate warning message telling user what exact parts of his input were not valid. The registration will not be able to be successful until all the fields are entered in a correct format.



Picture 3.4 - Invalid Input User Registration Screen

Once user successfully enters his/her information he/she receives a message that the registration was successful. In addition to the message on the screen, an e-mail is being sent to the user containing all his registration information. After registration user can log into the system by pressing the 'close and Log In' button. There's no need to enter username and password right after the registration.



Picture 3.5 - Valid Input User Registration Screen



After logging in user gets to the User Desktop which is the main screen of the program. This screen gives user access to all the possible services that PVA provides.



Picture 3.6 - User Desktop

User Desktop

The User Desktop is divided into six logical sections:

1. Header Bar

The header bar, which has the following information: first and last name of the currently logged user, information about upcoming holidays along with current time and date.

2. Quick Announcements Bar

This bar gives a short summary of the following three topics: special announcements, event reminder and messaging center. Special announcements are messages that were sent from the super user of the system. Event reminder is the section where see the upcoming events that you have added to your calendar. It helps you remember any important dates such as birthdays, meetings or important due dates. Messaging center shows you a quick summary of how many new e-mails you have in your mailboxes that you have linked to the PVA. In every of those three sections (special announcements, event reminder and messaging center) you can click on the button that is located next to the



topic and see the full section. For example if you click on the “view past announcements’ button next to the Special Announcements you will see the list of all the previous announcements that were made to this user. This section is currently under development

3. Main section panel

This section provides essential functionality of the system and contains the following options: Calendar, Time Recorder, Calculator, Digital Library, Send Quick Memo, Games, Instant messenger, E-Mail Center, and Video Conference.

Calendar – This option allows user to review calendar as well as gives the opportunity to keep track on any events that are important to remember. User can manage events by adding new event to the calendar, updating information for particular event or reviewing all the events that are saved.



Picture 3.7 – Calendar

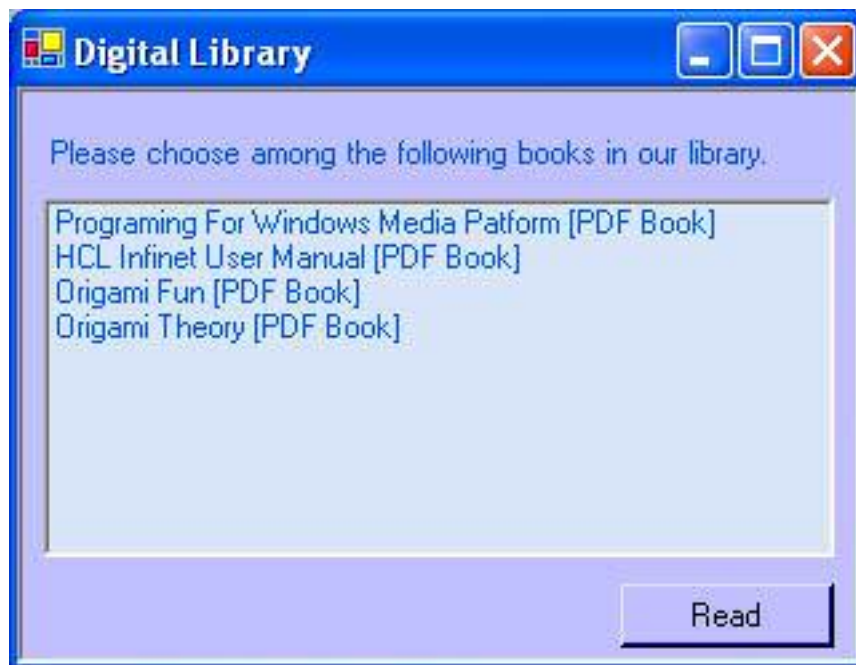
Time Recorder – Time recorder allows user to save time by using automated system for recording time when he/she comes to work as well as time when user goes home. In addition to time recording it allows to review weekly, bi-weekly and monthly timesheets as well as yearly W2 form sketch. User can print those forms at the end his pay period and submit to the supervisor. In the future the system will allow super user to digitally sign all the time sheets for every user that he needs.



Picture 3.8 – Time Recorder

Calculator – This is a basic calculator which allows making basic manipulations with numbers.

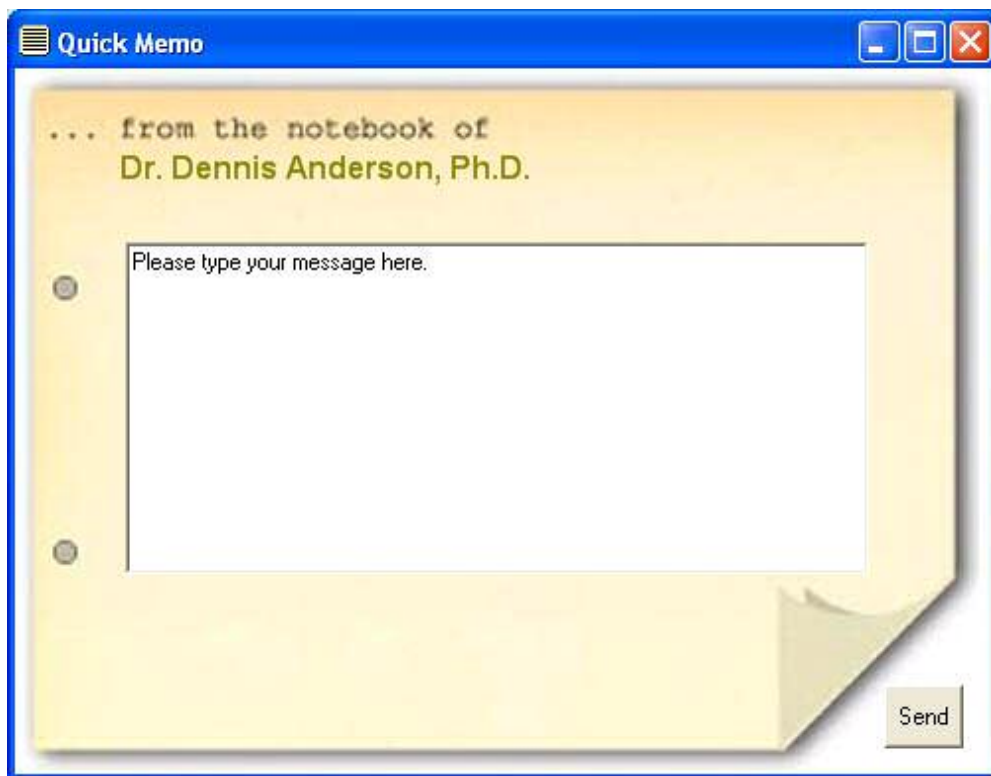
Digital Library – Digital Library allows user to browse through the books database and easily select the book that is relevant to the user. Since many books nowadays come in digital formats for example all the latest books from Microsoft come with the e-Book version it will be really handy to have the accessible to all the users without the need to have librarians and keep track on all the check outs. If the user has relevant permission he will be able to print either entire book or interesting chapters for farther review and save incredible amount of money on regular book maintaince.



Picture 3.10 – Digital Library



Send Quick Memo – This option allows user to deliver a quick note to the supervisor. Once you are logged into the system you can press the “Send Quick Memo” button which will open the screen with title that consists of the supervisor’s name so you will know who will receive your message, text box where you can type your message and a send button. Once you will start typing your message the VA will accompany you with the animation of writing a letter. This animation will be visible all the time that you will be typing. Once user finished typing the VA will stop writing and when the “send” button will be pressed the VA will notify user that his message is being send to the supervisor. In the same time on the back end the program will identify supervisors e-mail from the database and perform check if the network works and internet access is available. If the network is not available the VA will notify the user that the message was not sent. In case that the connection is available e-mail will be sent to the supervisor containing the text that the user has typed. E-mail will also include snapshot of the person and his e-mail as a reply e-mail address. Later we will add a small feature to the program that will store unsent messages in the outgoing folder and send them once the internet connection is reactivated.



Picture 3.11 – Quick Memo

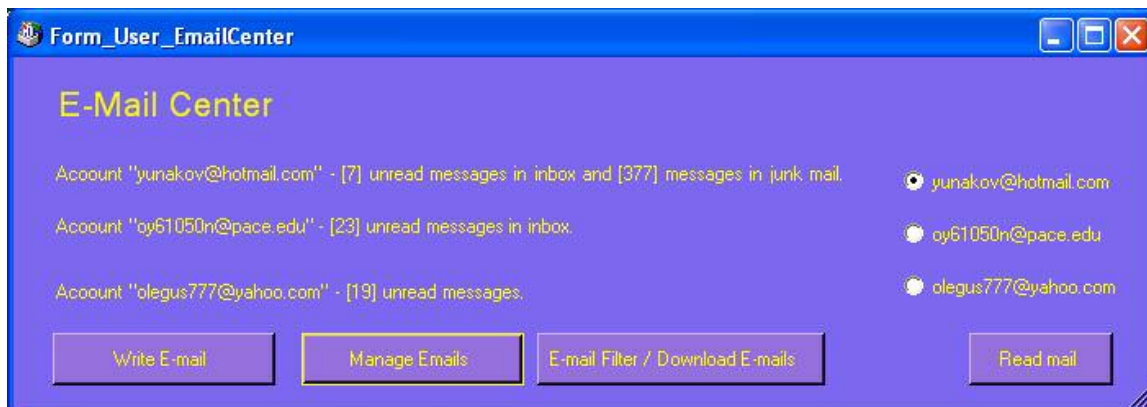
Games – This section is made to help users relax a little bit and play some games. Currently we provide the ability to play the following Microsoft games: FreeCell, Minesweeper, Solitaire and Pinball. In case of the need this option can be disabled by super user.



Picture 3.12 – Games

Instant Messenger – This option, which is under development, allows user to send an instant message to any of his friends or coworkers. In the future we will develop a local messaging system that will send messages to user using PVA clients or any of the major messaging solutions. Currently there is an option to log in to the AIM, MSN and send a message to the users that use those networks.

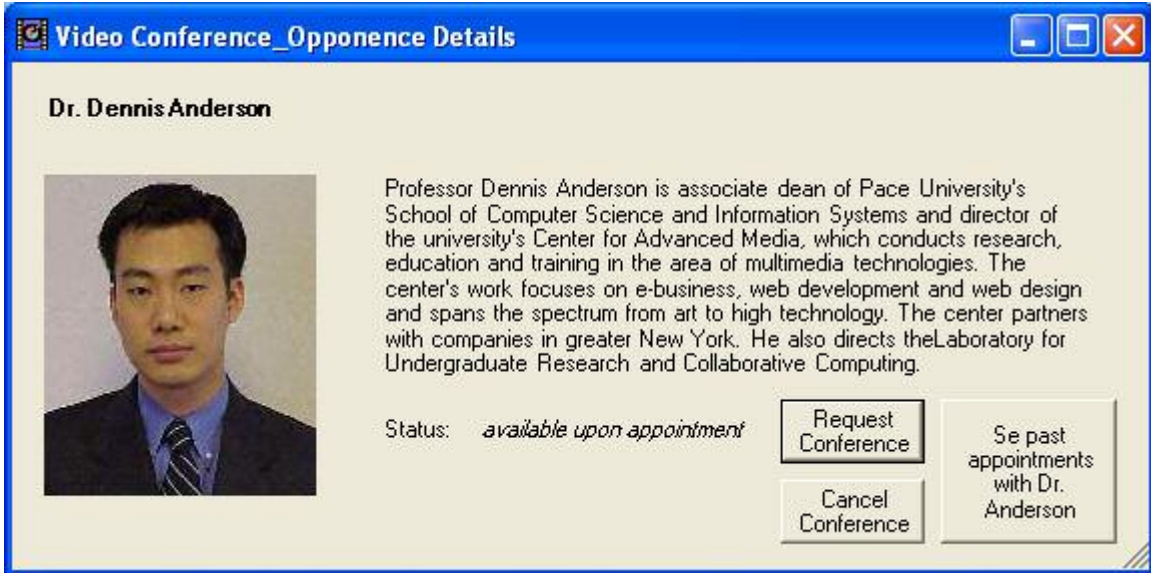
E-Mail Center – E-mail center allows users to collect e-mails from their e-mail accounts and read messages. In addition to that you can send e-mail from any of your e-mail addresses or send anonymous e-mails.



Picture 3.14 – E-mail Center

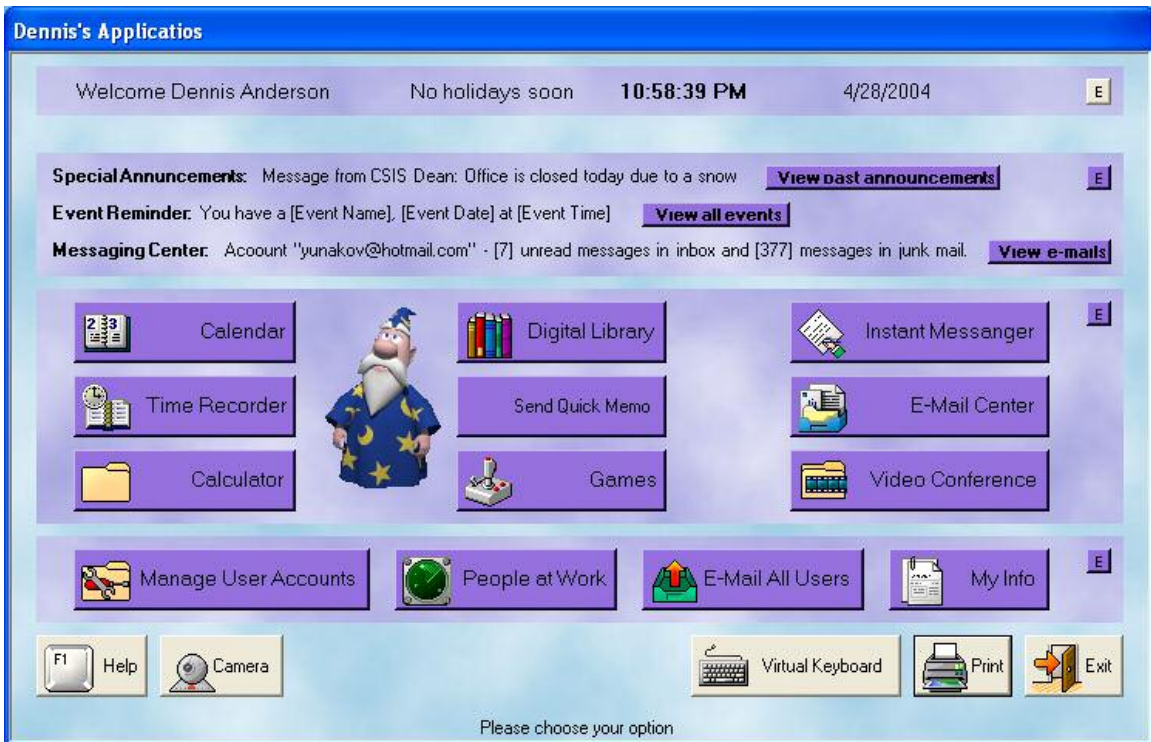


Video Conference – This module allows user to select people from the list of people who use PVA and add request fro a video conference. In case that the person has the status of accepting all incoming video conferences, the user can ask for an instant video conference with this person.



Picture 3.15 – Video Conference

4. Super User Panel



Picture 3.16 – Super User Desktop



The super user panel consists of the following four main options: Manage User Accounts, People at Work, E-mail all Users, and My Info.

Manage User Accounts – This category allows super user to manage accounts of all the people who use the system. Super user can view the information on any user of the system, can create new accounts, modify the details of any user including the permissions of the user. Super user can give super user's permissions to any of the users. Super user can also delete any of the users from the system. Super User can also disable registration for the new users and allow only already registered users to have access to the system.

People at Work – In this menu you can monitor the people who are currently at work and who signed up into the PVA web clients.

E-mail all Users – This option allows super user to send mass messaging to all the people who are registered in the system, or all the people who in the mailing list of the super user.

My Info – Current option allows super user to change his/her details such as his username, password, or e-mail. This option was available to every user until the decision was made to have this feature only for the super user. If regular users will want to make changes to their details they will need to contact super user with such request.

5. Support Bar

The support bar offers features such as: Help, Virtual Keyboard, Print and Exit. You can find more about Help and Virtual Keyboard in the Help Components section.

6. Footer Bar

The information about the footer bar can be found in the Help Components section.

GUI Considerations

During the design of the Graphical User Interface (GUI) there were several important details taken into the consideration. The main attempt was to make interaction with the system as easy and enjoyable as possible. The application was designed with keeping user needs in mind. Design doesn't limit user in his actions, but in the same time provides only essential functionality without confusion. The main aspect of the system is user's productivity, not the computer's. Design should be creative and smart with a look beyond just pure



math. Here is a very interesting example that shows why it's very important: "For example, which of the following takes less time? Heating water in a microwave for one minute and ten seconds or heating it for one minute and eleven seconds?"

From the standpoint of the microwave, one minute and ten seconds is the obviously correct answer. From the standpoint of the user of the microwave, one minute and eleven seconds is faster. Why? Because in the first case, the user must press the one key twice, then visually locate the zero key, move the finger into place over it, and press it once. In the second case, the user just presses the same key—the one key—three times. It typically takes more than one second to acquire the zero key. Hence, the water is heated faster when it is "cooked" longer.

Other factors beyond speed make the 111 solution more efficient. Seeking out a different key not only takes time, it requires a fairly high level of cognitive processing. While the processing is underway, the main task the user was involved with—cooking their meal—must be set aside. The longer it is set aside, the longer it will take to reacquire it.

Additionally, the user who adopts the expedient of using repeating digits for microwave cooking faces fewer decisions. They soon abandon figuring out, for example, whether bacon should be cooked for two minutes and ten seconds or two minutes and twenty-three seconds. They do a fast estimate and, given the variability of water content and bacon thickness, end up with as likely a successful result with a lot less dickering up front, again increasing human efficiency."

Another important issue is keeping user occupied all the time without making him waiting in front of the screen. If user will have to wait his productivity will go down because he will be annoyed. PVA masked all the delays in a very friendly way and uses the following trick. When screens are being changed or there is some kind of delay VA (Virtual Agent – more about it in the next section) performs relevant action which attracts the attention of the visitor and delay seems to be either smaller or becomes invisible. For example when user enters a correct password and the screens need to be changed, VA will clap his hands and several seconds of delay will not be noticeable. When user sends a quick memo and there is a delay as a result of the program trying to send the message, VA will say that the message is being sent.

PVA offers possibility to change background in order to allow user to customize screens and make them friendlier for the user. First three sections of the User Desktop can be customized by pressing the "e" button located at the top right corner of the panel. This allows user to order items of each section in a personal preferable way. It's also possible to remove different items from being displayed on the screen. In addition to this there were other important details taken into the consideration regarding readability of the text. Text that must be read should



have high contrast. Font sizes that were used are large enough to be readable on standard monitors.

Help Components

Three main help components of the PVA are: Virtual Agent, Footer Bar, Centralized Help, and Virtual Touch Screen Keyboard.

Virtual Agent –VA as an essential part of PVA is available throughout the entire application. VA improves visual user interaction with the system. In addition to providing comments it improves visual user interaction with the system it fills out all the delays of the system. For example when user is typing e-mail or a quick note VA will write in his book in the same time. When user has to wait between screens the VA will do some magic in his bowl. The agent can be hidden in any time by clicking on the agent with a right mouse button and selecting 'hide'. The agent was adopted from a Microsoft Word and reprogrammed or PVA through a custom written API.



Picture 3.21 - Virtual Agent

Footer Bar - Footer Bar is a sub-screen help line. This line will help you finding more about the option that is under your mouse cursor without performance of an extra click. This will help you determining if you need to click on a particular button and provides more information than just a name on the button.

Centralized Help - Centralized Help allows finding help on any particular part of the PVA system. Help is created in the Compiled HTML Help (.CHM) which is the latest accepted format for help which allows easy search as well as many other advantages such as printing.

Virtual Touch Screen keyboard – This keyboard utilizes the advantage of a touch screen and allows having a keyboard right next to the main screen buttons. You don't have to move your sight from the screen to a regular keyboard; you can just click on the graphical representation of the keyboard buttons. You can



use this keyboard along with the regular keyboard and press buttons with fingers or mouse pointer.



Picture 3.22 - Virtual Keyboard



Conclusions

As an outcome we got a prototype of PVA, a system that can be implemented in various fields. In education, it can be used to organize and ease student appointments with Deans or Chairs. In business, offices can use it in instead of a regular secretary. This assistant will never forget about the meeting and will be never tired. At the long term a global network of PVA's can be created allowing them to communicate between each other without need for appearance in person.



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Appendices

Appendix A – Review of Computer Vision Literature

Review of over 25 different papers from ACM and IEEE conferences as well as reading the book titled “Computer Vision” brought the following interesting aspects that can be used in an enhancement of the user identification algorithm

“Face Detection in Color Images”,

Rein-Lien Hsu, Mohamed Abdel-Mottaleb and Anil K. Jain, IEEE Trans. Pattern analysis and machine intelligence, Vol. 24, No. 5, pp. 696-706; May 2002

Categorizing face detection methods based on the representation used reveals that detection algorithms using holistic representations have the advantage of finding small faces or faces in poor-quality images, while those using geometrical facial features provide a good solution for detecting faces in different poses. A combination of holistic and feature-based approaches is a promising approach to face detection as well as face recognition. Motion and skin-tone color are useful cues for face detection. However, the color-based approaches face difficulties in robustly detecting skin colors in the presence of complex background and different lighting conditions. We propose a face detection algorithm that is able to handle a wide range of variations in static color images, based on a lighting compensation technique and a nonlinear color transformation.

Face detection algorithm contains two major modules: 1) face localization for finding face candidates and 2) facial feature detection for verifying detected face candidates. The algorithm first estimates and corrects the color bias based on a lighting compensation technique. The corrected red, green, and blue color components are then nonlinearly transformed in the YC_bC_t color space. The skin-tone pixels are detected using an elliptical skin model in the transformed space. The parametric ellipse corresponds to contours of constant Mahalanobis distance under the assumption of Gaussian distribution of skin tone color. The detected skin-tone pixels are iteratively segmented using local color variance into connected components which are then grouped into face candidates based on both the spatial arrangement of these components and the similarity of their color. The size of a face candidate can range from 13x 13 pixels to about three fourths of the input image size. The facial feature detection module rejects face candidate regions that do not contain any facial features such as eyes, mouth, and face boundary.

The appearance of the skin-tone color depends on the lighting conditions. We introduce a lighting compensation technique that uses "reference white" to normalize the color appearance. We regard pixels with the top 5 percent of the



luma (nonlinear gamma-corrected luminance) values in the image as the reference white only if the number of these pixels is sufficiently large (>100). The R, G, and B components of a color image are adjusted so that the average gray value of these reference-white pixels is linearly scaled to 255. The image is not changed if a sufficient number of reference-white pixels is not detected or the average color is similar to skin tone.

Among the various facial features, eyes and mouth are the most prominent features for recognition and estimation of 3D head pose. Most approaches for eye localization are template-based. However, we directly locate eyes, mouth, and face boundary based on their feature maps derived from both the luma and chroma of an image. We consider only the area covered by a face mask that is built by enclosing the grouped skin-tone regions with a pseudo convex hull.

Face Boundary Map and Face Score: We form an eye-mouth triangle for all possible combinations of the two eye candidates and one mouth candidate. Each eye-mouth triangle is verified by checking 1) luma variations and average gradient orientations of eye and mouth blobs, 2) geometry and orientation of the triangle, and 3) the presence of a face boundary around the triangle. A face score is computed for each verified eye-mouth triangle based on its eyes/mouth maps, ellipse vote, and face orientation that favors upright faces and symmetric facial geometry. The triangle with the highest score that exceeds a threshold is retained.

“Human Face Detection Using Geometric Triangle Relationship”,

Chiunhsiun Lin, Kuo-Chin Fan, IEEE Trans. Proceedings of the International Conference on Pattern Recognition (ICPR'00) 1051-4651/00

Automatic recognition of human faces is one of the most difficult and important problems in the areas of pattern recognition and computer vision. As we know, successful face detection process is the prerequisite to facilitate later face recognition task. Therefore, we should not treat face detection process merely as preprocessing a face recognition system. On the other hand, we should deal with face detection problem as important as the face recognition problem. Abundant of researches has been conducted on human face detection.

The main purpose of this process is to find the regions in an input image that might potentially contain faces. There are four steps in the first part of the designed system. Firstly, read in an image, it could be either a color or gray level image. Then, convert this input image to a binary image. If this input image is not a grayscale image, transform the input image to grayscale format, and then convert this grayscale image to binary image by thresholding. Secondly, label all 4-connected components in the image to form blocks and find out the center of each block. Thirdly, detect any 3 centers of 3 different blocks that form an



isosceles triangle Fourthly, clip the blocks that satisfy the triangle criteria as the potential face region.

Then we preprocess the inputted image to a binary image. In this step, we first convert the input image to a binary image. For example, when we read in a RGB color image, we will preprocess the input image to gray level image by eliminating the hue and saturation information while retaining the luminance. Then, binarize the gray level image to a "binary image" by simple global thresholding with threshold T because the objects of interest in our case are darker than the background. Before proceeding to the next step, we perform the opening operation (erosion first, then dilation) to remove noise, and then the closing operation (dilation first, then erosion) to eliminate holes.

2.2. Label all 4-connected components and find the center of each block

Here, we use raster scanning (left-to-right and top-to-bottom) to get 4-connected components, label them, and then find the center of each block. The detail of raster scanning can be found in [13].

2.3. Find any 3 centers of 3 different blocks that form an isosceles triangle

From careful observation, we discover that two eyes and one mouth in the frontal view will form an isosceles triangle. This is the rationale on which the finding of potential face regions is based. We could search the potential face regions that are gotten from the criteria of "the combination of two eyes and one mouth".

2.3.1. The matching rules for finding an isosceles triangle

If the triangle $i j k$ is an isosceles triangle as shown in Figure 2(a), then it should possess the characteristic of "the distance of line $i j =$ the distance of line $j k$ ". From observation, we discover that the Euclidean distance between two eyes (line $i k$) is about 90% to 110% of the Euclidean distance between the center of the right/left eye and the mouth. Due to the imaging effect and imperfect binarization result, a 25% deviation is given to absorb the tolerance. The first matching rule can thereby be stated as $(\text{abs}(D(i, j) - D(j, k)) < 0.25 * \max(D(i, j), D(j, k)))$, and the second matching rule is $(\text{abs}(D(i, j) - D(i, k)) < 0.25 * \max(D(i, j), D(j, k)))$. Since the labeling process is operated from left to right then from top to bottom, we can get the third matching rule as " $i < j < k$ ". Here, "abs" means the absolute value, " $D(i, j)$ " denotes the Euclidean distance between the centers of block i (right eye) and block j (mouth), " $D(j, k)$ " denotes the Euclidean distance between the center of block k (left eye) and block j (mouth), " $D(i, k)$ " represents the Euclidean distance between the centers of block i (right eye) and block k (left eye). For example, as shown in Figure 2(b), if three points (i, j , and k) satisfy the matching rules, then we think that they form an isosceles triangle. After we have found the isosceles triangle, it is easy to get the coordinates of the four corner points that form the potential facial region. Since we think the real facial region should cover the eyebrows, two eyes, mouth and some area below mouth [9], the coordinates can be calculated as follows. Assume that (X_i, Y_i) , (X_j, Y_j) and (X_k, Y_k) are the three center points of blocks i , j , and k that form an isosceles triangle. (X_1, Y_1) ,



(X_2, Y_2) , (X_3, Y_3) , and (X_4, Y_4) are the four corner points of the face region as shown in Figure 3. X_1 and X_4 locate at the same coordinate of $(X_i - 1/3 * D(i, k))$; X_2 and X_3 locate at the same coordinate of $(X_k + 1/3 * D(i, k))$; Y_1 and Y_2 locate at the same coordinate of $(Y_i + 1/3 * D(i, k))$; Y_3 and Y_4 locate at the same coordinate of $(Y_j - 1/3 * D(i, k))$; where $D(i, k)$ is the Euclidean distance between the centers of block i (right eye) and block k (left eye).

“Face Detection and Synthesis Using Markov Random Field Models”,
Sarat C. Dass, Anil K. Jain, and Xiaoguang Lu, Proceedings of the 16th International Conference on Pattern Recognition (ICPR'02), 1051-4651/02

Numerous attempts have been made in recent years to detect human faces in images using a variety of techniques. Some of the approaches include face detection algorithm based on neural networks, tree classifiers, distance from prototype criteria and Markov Chains. However, the inherent spatial nature of digital images makes Markov Random Fields (MRFs) a natural choice for modeling the distribution of gray levels on face images. Preliminary results indicate that the approach to detecting faces using MRFs appears promising. However, to circumvent the computational requirements, the MRFs used before were only a valid approximation. In this paper, we develop exact estimation procedures that lead to parameter estimates for the actual MRF model. Two classes of auto-MRF models, based on the first- and second-order neighborhood structures, are of interest. An immediate advantage of this stochastic approach over previous is that now we are able to simulate face-like images from the estimated MRF models and increase the number of training samples in both the face and non-face data bases. We investigate if subsequent re-estimation of model parameters and detection show a significant reduction of error rates for test images.

The MRF models used here do not utilize high level facial features for the purpose of face detection. Indeed, our aim here is to provide an initial low-level detection algorithm. In the post processing stage, algorithms based on facial features (e.g., eyes and mouth) can be utilized to finally decide if a face is indeed present in the test image. For this reason, we put greater emphasis in developing algorithms with low false negative rates in the detection framework. We also adopt the best discriminating MRF approach reported in [5] where the most discriminating permutation of the sites is used compared to the natural order of site pixels.



Appendix B – Main User Identification System Algorithms

User Detection Algorithm

1. Begin User Detection Process
2. If CAMERA_OUTPUT != CONSTANT_VALUE then
 - 2.1. DETECTION = True
3. End If
4. While DETECTION is true do
 - 4.1. If ACTIVATION_SIGNAL is true then
 - 4.1.1. Get USERS_HEIGHT
 - 4.1.2. If !(USERS_HEIGHT - CAMERA_HEIGHT) MOD 5 then
 - 4.1.2.1. CAMERA_HEIGHT = CAMERA_HEIGHT + (USERS_HEIGHT - CAMERA_HEIGHT)
 - 4.1.3. Else
 - 4.1.3.1. For I = 1 to 6 do
 - 4.1.3.1.1. USER_PIC[i] = CAMERA_PIC
 - 4.1.3.1.2. CAMERA_PIC = new CAMERA_PIC
 - 4.1.3.2. End do
 - 4.1.3.3. For I = 1 to 6 do
 - 4.1.3.3.1. If OPEN_EYES and CENTERED then
 - 4.1.3.3.1.1. PIC[j] = USER_PIC[i]
 - 4.1.3.3.2. End If
 - 4.1.3.4. End do
 - 4.1.4. End If
 - 4.2. For I = 1 to 6
 - 4.2.1. If (PIC[i].CONTRAST < MIN_CONTRAST) or (PIC[i].CONTRAST > MAX_CONTRAST)
 - 4.2.1.1. PIC[i].CONTRAST = ADJUSTED_CONTRAST
 - 4.2.2. End If
 - 4.2.3. If (PIC[i].BRIGHTNESS < MIN_BRIGHTNESS) or (PIC[i].BRIGHTNESS > MAX_BRIGHTNESS)
 - 4.2.3.1. PIC[i]. BRIGHTNESS = ADJUSTED_BRIGHTNESS
 - 4.2.4. End If
 - 4.2.5. If (PIC[i]. CENTERED < MIN_CENTERDED) or (PIC[i]. CENTERED > MAX_CENTERED)
 - 4.2.5.1. PIC[i]. CENTERED = ADJUSTED_CENTERED
 - 4.2.6. End If
 - 4.2.7. If (PIC[i]. ZOOM < MIN_ZOOM) or (PIC[i]. ZOOM T > MAX_ZOOM)
 - 4.2.7.1. PIC[i].ZOOM = ADJUSTED_ZOOM
 - 4.2.8. End If
 - 4.3. End If
5. End While
6. End User Detection Process



User Identification Algorithm

1. Begin User Identification Process
2. Improve Captured Images
 - 2.1. Enhance the contrast
 - 2.2. Enhance the intensity (brighten or darken the image)
 - 2.3. Move the face to center and crop
 - 2.4. Zoom in the image to fit the standard dimensions
 - 2.5. Manual edit. (UIS allows manual edition of the pictures in the database. This is optional)
3. Access Users Database
4. For every image in the database perform compare images techniques:
 - 4.1. Face edge detection
 - 4.2. Face proportion detection
 - 4.3. Eyes comparison
 - 4.4. Identification of eye brows and comparison by width and length
 - 4.5. Detection of mouth and identification of it's length
 - 4.6. Eye-nose relativity
 - 4.7. Nose detection and height measurement
 - 4.8. Side shape of ear comparison.
 - 4.9. Advanced mathematical matching algorithms. This is the most accurate part of image comparison. Algorithms will include matrix comparison of both images using the number values for brightness of every pixel of the image.
5. If user was detected and captured image matches image in the database then
 - 5.1. Retrieve User's ID from the Database
 - 5.2. If there are twelve images in the users database
 - 5.2.1. Delete the images that have lowest detection ration and are oldest.
 - 5.2.2. Add three captured images to the database
6. If User was not detected than
 - 6.1. Set User's ID to the "N/A"
 - 6.2. Create new Users Entry in the database
 - 6.3. Add three captured images to the database
7. End User Identification Process



User Greeting Algorithm

1. Begin User Greeting Process
2. If Users ID is not "N/A" then
 - 2.1. Access Database
 - 2.2. Get Users Name from the Database
 - 2.3. Get History of Previous meetings from the database
 - 2.4. Check if the user have current meeting in history
 - 2.5. Great user
 - 2.6. Ask if he is the correct person
 - 2.6.1. If he is not the correct person then:
 - 2.6.1.1. Add false detection to chosen User ID.
 - 2.6.1.2. Change User ID to "N/A".
 - 2.6.2. Else (if he is the correct person):
 - 2.6.2.1. Provide user with relevant possibilities for future interaction.
3. Else (if users ID is "N/A"):
 - 3.1. Greet User
 - 3.2. Ask user for his name
 - 3.3. Ask if he is a new user
 - 3.3.1. If new user than:
 - 3.3.1.1. his name to the database
 - 3.3.2. Else (if not a new user):
 - 3.3.2.1. Delete new user's entry in the database.
 - 3.3.2.2. Ask for his name
 - 3.3.2.3. Ask for his user ID
 - 3.3.2.4. Update field of not detected for this user ID
4. End User Greeting Process



Appendix C – Data Flow Diagrams

