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DEVELOPMENT OF ROBOT TO MIMIC HUMAN WRITING

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ABSTRACT: This is an approach to design rapid and fluid movement of an universal robot to mimic human writing. Reading a doctor's handwritten prescription is a challenge for most of the patients and in some cases it leads to negative consequences due to wrong deciphering of the prescription. Part of the reason why doctor's prescriptions are so difficult to decipher is that doctors make use of Latin abbreviations and medical terminology that most people don't understand. This can be overcome by this universal robot which mimics the writing of doctors while doctors are prescribing the medicine orally. To perform the task, on-line voice conversion standards are created first. After that robot writing task is performed using the standards and then the robot written are acquired as a result. Finally, recommendations of robot motion improvement are given.

KEYWORDS

Universal robot, voice conversation, robot writing, control, mimicking human functions

I. INTRODUCTION

Mimicking human functions of handwriting is a challenging task for robots. The task is also actual for biometrics which deals with the measurement and statistical analysis of people's physical and behavioral characteristics/traits. Even for a man, it takes a long time to learn how to manipulate a pen to perform rapid and fluid writing movements to produce appropriate smooth sequences of letter signs such as in a human signature. Nowadays, there are many approaches employed in robotics to mimic human writing. The approaches relied on precise position-controlled robots are among them [1-5]. Such robots employment guarantees that the robot pen will be in contact with the writing surface but requires fine calibration of the drawing pad. In this work, we use universal robot aimed to transfer natural human kinematics and trajectories when writing while exploiting contact with a writing tablet, Wacom Intuos Pro tablet in our case.

On-line human signing standards are firstly created in order to mimic human handwritten signatures. Robot writing is performed using these standards after that and robot signatures are acquired as a result. Next, both human and robot signatures are analyzed and compared and degree of signatures correlation is defined. Finally, recommendations of robot writing motion improvement are presented.

II. WORKING PHASE

When a robot is designed the most important thing to be kept in the mind is the functions to be performed by robot images.

A. Handwriting Specimen Acquisition

This phase contains a human signing (writing) process using any device such as LCD touch pad, Wacom, handheld, etc. In our case, performed on-line human writing specimen, i.e. signature, is captured by Wacom tablet, which registers the pen-tip trajectory (x, y coordinates) as well as the pen pressure signal (p). For each acquired specimen, a file with the trajectory and pressure coordinates is generated. The signatures are acquired dynamically, i.e. using a specific sampling rate (100 Hz). The registered trajectory is divided into two types: Pen-downs ($p>0$) and Pen-ups ($p=0$).

B. Writing Specimen Acquisition

Captured writing specimen is processed using original program units developed in IDeTIC, ULPGC. The acquired signature is analyzed. As a result, corresponding signature trajectory and speed profiles are generated.

C. Robot Writing

UR5 robot performs a writing process according to the acquired signature specimen. Signature trajectory coordinates are taken from an acquired file and put to the input of robot control system (Fig.2). Next, the robot writing process is realised using Wacom tablet. A special pen for robot writing was designed and constructed in a laboratory environment (see Fig. 3). After that, the robot writing specimen is processed similarly as for the human writing specimen (phase B).

D. On-line Human and Robot Signatures

The parameters of human on-line and robot writing specimens (results of phases B and C) are compared and analysed. The degree of closeness of the human and robot is defined by the velocity and the trajectory. They are measured by the Signal-to-Noise-Ratio (SNR), as it was suggested in [8-9]. Let the sub-indexes *h* and r be the human and the robotic signals, we then define the SNR between velocity profiles as SNRvand the SNR for trajectories as SNRt. There are particular equations for the calculation of signal to noise ratio for velocity and for trajectories. The equations are given below.

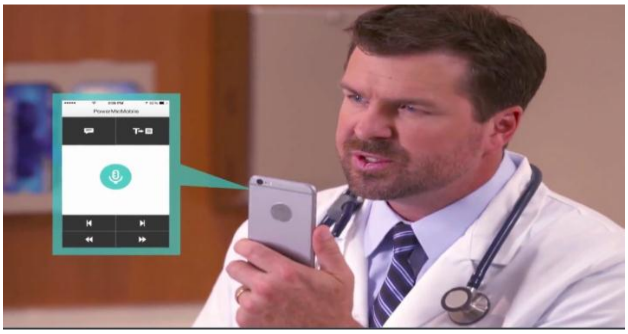
$$SNR_v = 10\log\left(\frac{\int_{t=0}^{T} v_h(t)^2 dt}{\int_{t=0}^{T}(v_h(t)-v_r(t))^2 dt}\right) \quad (1)$$

$$SNR_t = 10\log\left(\frac{\int_{t=0}^{T}(x_{hm}(t)^2+y_{hm}(t)^2)dt}{\int_{t=0}^{T}(x_{hr}(t)^2+y_{hr}(t)^2)dt}\right) \quad (2)$$

III. ROBOT CONTROL IN A WRITINGPROCESS

Experimental robotic setup

The setup consists of stepper and servo motor connected to the hardware setup and a Wacom tablet. The motors are mounted on opposite sides of the board diagonally, such that their Base frame Y axes point away from the table. There is an arduino board which comprises the hardware setup of the module. Arduino refers to an open source electronic platform or both and the software used to program it. The motors are controlled by the driver ULN2003APG. ATMEGA is to control the entire action which can take inputs from the device they control and retain control by sending the device signals to different part of the device.



The particular usage of ATMEGA328 micro controller is that it is an inbuilt hardware in every voice to text conversion .The Bluetooth module, a wireless product is a high speed low powered wireless technology link that is designed to work with phones or other portable devices within a short range of distance, When the power supply is given to the device, the Bluetooth in the device as well as the Bluetooth in the smart phones are turned on so that when the words are pronounced in the phone's microphone they are transferred to the device's Bluetooth which finally gives instructions to the motors through the drivers in the arduino board. The motors which is attached to the pen starts it's motion.

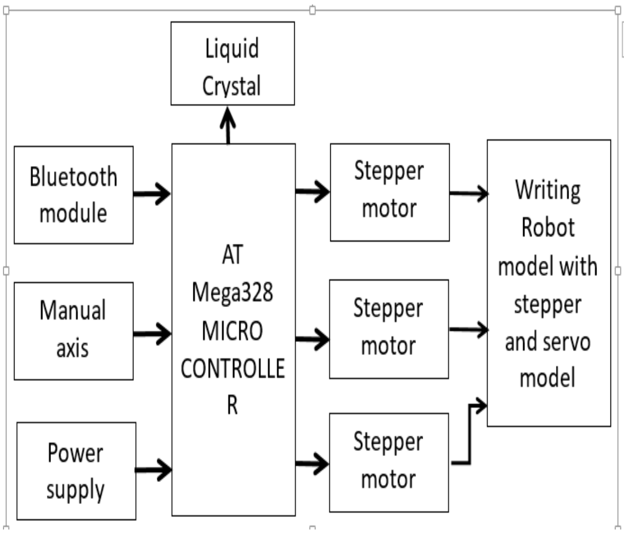


Figure 2: Block Diagram of the Proposed System.

The mobile phone are provided with an application software where a program is embedded to allow the processing of speech input to text. The pen attached to the motors starts to write in X and Y axis. The X axis is controlled by the servo motor and the Y axis is controlled by the stepper motor. These two motors are linear actuators that allows a precise control of angular or linear position and acceleration

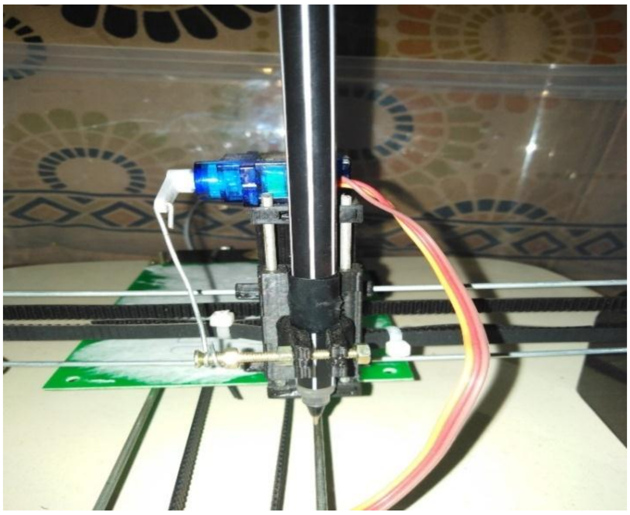
IV. ROBOT WRITING PROCESS

Processes of robot writing were realized using experimental setup described above, which contains universal UR5 robot, Wacom Intous Pro M tablet, control PC, UR5 controller unit and Polyscope control panel (Fig.2). The process starts with the downloading of the writing text parameters which are the results of the previous human or robot writing processes, or a new composition of the writing symbols presented in the database.

Control of the robot writing process is realized by a program unit developed using embedded C language via control PC connected with ATmega328 microcontroller by Bluetooth. Robot displacements command (described above in section 3.1) are sent to ATmega328 which generates and sent control commands to robot drives

While performing writing process, UR5 robot executes a Program written in URScript code. URScript program content is based on the control program created in the embedded C language and sent to UR5 controller.

Therefore, the presented UR5 control program allows writing of symbols sequences, i.e. text elements, which are read from a specially prepared symbols database. Execution of specific inscriptions written as whole, e.g. robot-written signatures, is also performed.



V. CONTROL PROGRAMS INTERACTION

The general scheme of the program run for the robot writing control is as follows. First, the program variables which define the way of the program run are assigned and downloaded. Next, a "data sources" variable (specifying whether a data is read from a single file or individual letters (or strokes) are read from different files to realize the complex sequence of text symbols), as well as methods of data loading are defined. After that, writing of loaded signature symbols is performed by linear motion of UR5 robot pen with simulations checking if the final and each predefined position of robot end-effector are reached.

In this communication technology, to follow a present order of appropriate symbols writing it is necessary to control the moment when a next data set of the following symbol (or stroke) to be written is sent to the UR5 robot controller. This control was realized owing to the possibility of robot positions reading and defining characteristics points in which robot end-effector is placed after finishing of each signature symbol writing and do not reach while writing.

VI. EXPERIMENTALRESULTS

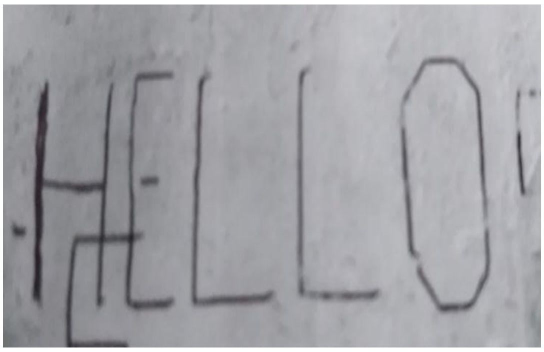
While performing laboratory experiments, sever all Human on-line and root writing specimens were all are acquired and evaluated. Quality measures of one of the robot writing examples, i.e. 'HELLO' written with the specimen, for three different speed writing modes is presented in Table 1. Corresponding fraphs of 10 and 100 speeds writing modes performed both by man and UR5 robot are given in the Table 1.

TABLE 1.QUALITY MEASURES OF THE ROBOT WRITING EXAMPLE

Writing speed	*Quality of speed profile (dB)*	*Quality of trajectory profile (dB)*
10	*1.0304*	*24.4948*
50	*3.6204*	*1.7375*
100	*4.021*	*-2.9281*

Therefore, we suppose that a reasonable way of increasing of quality of the speed profile is the reduction of inertia of robot arm parts in parallel with optimal task placement in robot workspace. For this aim it is necessary to find an appropriate quality index (e.g. minimum of inertia) to perform an optimization task. That will be one of the directions of our future research. Improving of the effectiveness of dynamic signature verification system is also among the future tasks. While performing laboratory experiments, several human on-line and robot writing specimens were acquired and evaluated.

Quality measures of one of the robot writing examples, i.e. 'HELLO' written specimen, for three different speedwriting modes is presented in Table 1. Corresponding graphs of 10 and 100 speeds writing modes performed both by man and UR5 robots are given.



VII. CONCLUSIONS

This paper presents a method to design rapid and fluid movements of a universal robot to perform robot writing mimicking the kinematics and trajectory of human handwritten signatures. The handwriting specimen acquisition, writing specimen processing, robot writing and comparison of on-line human and robot signatures are the phases of the experimental research performed. The phases are the steps of the presented method implementation. In the given paper, more attention was paid to the technology of written specimens' processing, experimental robotic set-up description as well as the control process of UR5 while performing writing task.

Obtained human and robot writing specimens were processed. Acquired human and robot writing trajectory and speed profiles were compared and evaluated. Quality of the obtained robot trajectory profile is high. The increasing of the quality of robot speed profile by the reduction of inertia of robot arm parts in parallel with optimal task placement in robot workspace was defined as the future direction of the presented research.

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