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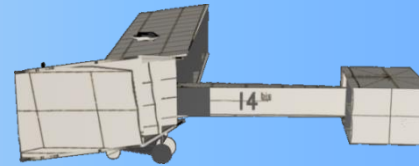
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Automated Extraction Information System from HUD's Images using ANN

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Summary

- Introduction
- HUD System
- Application
- Challenges
- Algorithm
- Character Recognition
- Word Recognition
- Discussion



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Introduction

- **Motivation:**
 - The execution of experimental Flight Test Campaign (FTC) provides all information required for the aircraft and/or its systems development, operation, certification and qualification.
 - For tactical operations, the Head-Up Display (HUD) is a key element to provide essential information for the pilot during the navigation and weapon enforcement flight regimen.
 - HUD projects navigation and weapon information in a user-defined symbolic form
 - Various FTC (e.g. weapon aiming) requires the analysis of HUD images



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Introduction

- **Motivation:**
 - Therefore, a simple nonintrusive Flight Test Instrumentation (FTI) data gathering technique for such information is to record the HUD video frames and to embed such information into the FTI measurement set for post mission data analysis
 - Analysis is typically qualitative, where frames are manually observed and analyzed for information extraction
 - This process is very ineffective because in one flight test hour it 36,000 frames are generated
 - the data analysis process becomes complex, time consuming and suitable to failures



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Introduction

- **Solution:** IPEV and ITA developed an image processing application with pattern recognition using the correlation process to extract information from different positions of the HUD images.
 - Image processing techniques
 - Classifier based on correlation to recognize words
 - Artificial Neural Network (ANN) to recognize characters



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HUD System

- There are 26 letters and 10 numbers.
- All images of the characters must be normalized to the same size before using them in neural network training or testing.
- The most commonly used images in pattern recognition are binary images. Binary images require less computational intensity compared with other types of images
- The neural network was initialized using Nguyen–Widrow algorithm, where the weights and biases in each layer are initialized and distributed approximately evenly over the input space



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Application

- A HUD embedded in EMBRAER A1 aircraft was used
- The HUD recorded into the camera's buffer all images of the test flight. Then recorded video is downloaded to the computer through its USB interface.



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Challenges

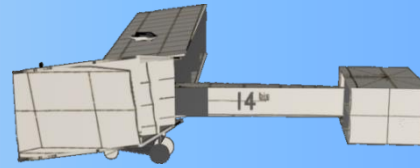
- The scenario has a complex background that could change very rapidly which can result in significant change of lighting





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Challenges

- **Process images to obtain better accuracy even in frames not cleaned (e.g. blurring, overlapping objects).**
- **Transitions between images produced by the HUD generate blurring areas.**



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Algorithm

- Although there are different patterns of images produced by HUD, all images have text in preset positions

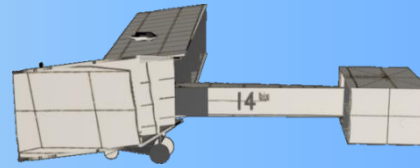


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Algorithm

- 1. The video produced by HUD is converted to PNG (Portable Network Graphics) images;
- 2. The image template for each character and word are loaded from the database;
- 3. The HUD images are loaded in the application;
- 4. Each image is processed using steps:
 - a. Threshold is applied to obtain a binary image;
 - b. Adjustments are applied to the image depending on the gray level, background and histogram of the image;



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Algorithm

- c. Identify setup mode because for each mode the set of information in the image is different.
- d. Character and word segmentation.
- e. Word recognition.
- f. Character recognition. Use of the ANN algorithm.
- g. The results are stored in an array structured with all the information recognized.
- 5. The results of the array can be visualized



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Character Recognition

- 01 ANN was trained to recognize 36 different characters:
26 uppercase letters and 10 numbers.

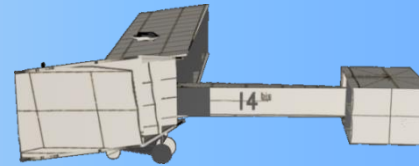


Samples of letters and numbers used by the HUD





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Character Recognition

- 6,998 binary images were used.
- Database had two non-overlapping groups.
- First group with 2,772 characters which is used only for neural network training.
- Second group with 4,226 characters, which is used only for neural network testing.

	Samples
Training group	
Testing group	



Word Recognition

- For the recognition of words a correlation algorithm was used

$$r = \frac{\sum_m \cdot \sum_n (A_{mn} - \bar{A})(B_{mn} - \bar{B})}{\sqrt{(\sum_m \cdot \sum_n (A_{mn} - \bar{A})^2)(\sum_m \cdot \sum_n (B_{mn} - \bar{B})^2)}}$$

- For this algorithm step, a database of templates was created for each word. Table shows examples of the words that can appear in each image region

Region	Words
Menu	MAIN, NEW TARGET, TGT
Top	AREA, INR, POINT, SLEW, SLV TGT, SLV VIS
Setup Mode	AG, LITEN IBIT, LITEN NTO, LITEN STBY
Middle	FLIR HOT, MASK
Track Mode	TRK AREA, TRK POINT



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Discussion

- The evaluation of this application was performed with HUD images produced by EMBRAER A1 (AM-X) aircraft, during the Brazilian Flight Test Course (CEV) carried out by the 2013 class students.
- In addition, the application was developed under MatLab® environment and tested with Intel®Pentium IV notebook and it was evaluated with more than 10,000 HUD frames



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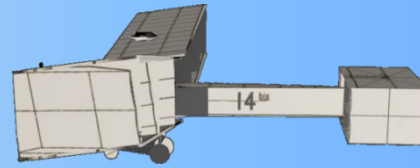
Discussion

- The 39.61% training data was divided into three subsets, where 80, 15 and 5% data was used for training, validation and testing, respectively
- The maximum iterations, performance goal and minimum performance gradient are set to 1000, 0 and 1×10^{-6} , respectively,
- The maximum validation failure σ and λ are set to 6, 5×10^{-5} and 5×10^{-7} , respectively.
- The achieved training, validation and testing successful rates are 99.65, 99.67 and 99.74%.
- In order to obtain more accurate performance of the trained neural network, another non-overlapping testing data set are used for the testing



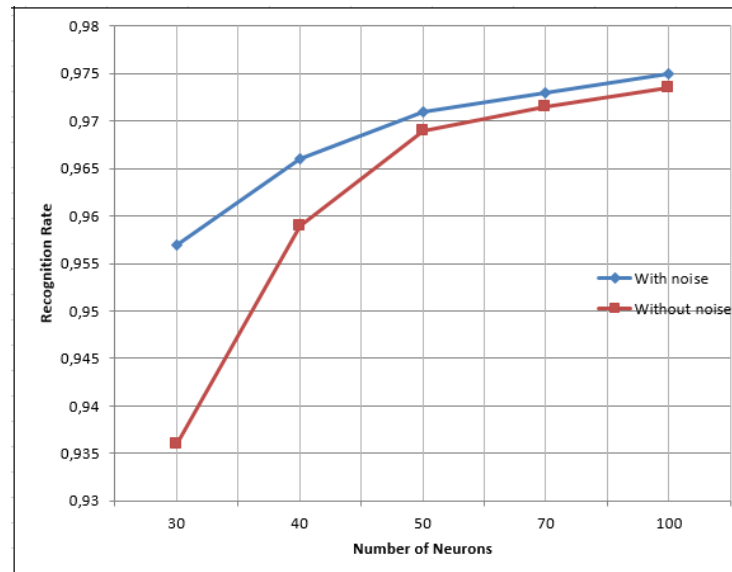
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Discussion

- The rest of the 60.39% of character images were used for testing trained neural networks with different sizes (i.e. 30, 40, 50, 70 and 100 neurons) and training sets (i.e. with and without noise added)
- Overall character recognition rate of the 60.39% testing data are around 96.8%



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Discussion

- Table shows the recognition rate of each word using the proposed algorithm.
- The algorithm for word recognition was setup to discard the image if the correlation coefficient (“r”) is less than 0.5.
- After evaluation, it was realized that the algorithm could validate 99.7% of words in the frames

	Menu	Top	Setup Mode	Middle	Track Mode
recognition rate (%)	100	99,5	99,1	100	100



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Discussion

- In Fig. depicts an example of a single frame image processed by the application and the results. The usage of this application resulted in satisfactory performance



```

frame: 35679.png
top: area
left: ag
middle: -
trk: trkarea
cardinal point: w
menu: tgt1
altitude: 566
feet: 1015
azimuth: 7
elevation: -4
coordinate south: 29.53.953
coordinate west: 054.55.330
hour: 18:46:24
radius: 43.0

```



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Summary

- Usage of image processing and pattern recognition in images from HUD produces results that can increase flight tests efficiency.
- This paper proposed an automatic recognition system for text image recognition, based on a specific correlation algorithm and an ANN.
- The application allows reduction of processing time in post-mission operations for data extraction from HUD images



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Summary

- As future work:
 1. Different strategies for pattern recognition (e.g. different ANN models) should be evaluated;
 2. It is possible to use parallel processing techniques to improve image processing efficiency; and
 3. Different setup schemes for post processing to improve the accuracy index should be experimented



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