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GESTURE RECOGNITION BASED AC MOTOR SPEED CONTROL

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ABSTRACT

For increasing/decreasing the ceiling fan speed or for switching the lights ON/OFF mostly we need to get up and move towards the switch board. But the ones who are physically impaired, it's difficult for them to do so. This system is targeted mainly to help people who are physically impaired& unable to operate the switch board easily for controlling the ceiling fan speed & turning the lights ON/OFF. It's also possible to control these electronic equipment with the help of wireless technique like remote control. But the problem here is, due to different physical shapes of device and a variety of functional commands that each remote control features gives rise to numerous problems: the required remote control locating difficulties, the button layout confusion, the device replacement issue and so on. The proposed model for AC motor speed control of ceiling fan based on image processing is a recent innovative user interface that resolves the complications of using numerous remote controls for domestic appliances. Using one unified set of hand gestures, this system can interpret the hand gestures of user into pre-defined commands to control one or multiple devices at the same time. The experimental results are highly encouraging as the system is able to produces real-time responses and accurate recognition towards various set of gestures to perform the respective task.

KEYWORDS: Firing Angle, Feature Extraction, Gesture Recognition, Image Processing Techniques, Segmentation, SIFT.

I. INTRODUCTION

Until now, Hand Gesture Recognition technology is implemented with the help of "Data Gloves" or "Color pins" which leads to increase in cost and the availability of these devices among majority of masses is negligible. Also, the use of additional devices increases the maintenance cost. Today to get a webcam is a very easy task, since it's available easily in the market. In our project, we have implemented a hand gesture recognizer as shown in Fig. 1 which is capable of detecting a hand gesture, where webcam is used as an input device. In future, instead of using regulator or remote control for interacting with machines, it will be more comfortable and natural approach for us to communicate with bare hands without the interaction of any mediator. As a result of discussion until now, hand gesture recognition is asatisfactory solution, instead of using devices like regulators, remote control & mechanical switches as input devices. Since, for gesture processing & recognition low power to process is required, which seems to be useful for simple consumer control devices.

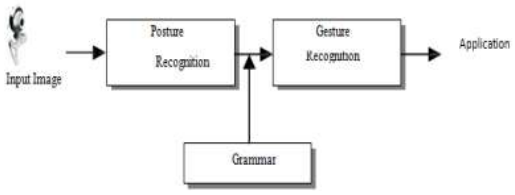


Fig. 1 Hand Gesture Recognition System

In image processing based hand gesture recognition system, the hand gesture is recorded by video camera. Then this input video is decomposed in such a way that we are able to extract the required set of features from the acquired image. The hand is separated from the background by using image processing technique.

The separated handis recognized for different postures. Since, as we know a sequence of hand poster which is connected by continuously changing motions forms a gesture. Here a recognizer needs to be trained by using something called as grammar. The hand gesture is nothing but building up from the group of hand postures in various composition, just like a group of words make a phrase. The recognized gestures is used to drive applications like household appliances. The image processing technique for gesture recognition process can be decomposed into three main stages as follows:

- ✓ Acquired image preprocessing and segmentation,
- ✓ Feature extraction& classification, and

- ✓ Hand gesture interpretation to actuate the device.

The discussion until now have yielded a result that gesture recognition using image processing technique can be one of the advanced technology to operate the machines. The main aim of this paper is to control the AC motor speed using gesture recognition technique, which can be done by the using image processing. There are multiple ways to control the speed of an induction motor such as H-bridge inverter; 3 phase Inverter Bridge,Volts/Hertz control method, phase control method and etc. However in this paper, our area of interest is to review and apply the advanced speed control method forAC motor – implementation of image processing technique for hand gesture recognition, which then gives an output to the controller system which controls the duty cycle in order to vary the speed of AC motor.

II. LITERATURE SURVEY

Gesture recognition is a recent & innovative area of research nowadays. To control machines, researchers have long tried to replace the remote controls, switches& regulators using voice recognition or glove-based services. A brief review research work carried out in the field of household appliances control using gesture recognition & other techniques are given below.

D. Vishnu Vardhan & P. Penchala Prasad[1] proposed model, a communication system which converts signal languages, used by dumb people. Flex sensor is used to sense the hand gestures in this project.A gesture recognition algorithm which works automatically, is developed to identify individual gestures in a sequence. Finally, the gesture is recognized by comparing the acceleration values given by the sensors with the stored templates in the database. According to recognized gesture, respective commands are played through speaker with the help of voice chip. The above proposed technique for the use of flex sensors is also used by K.C. Shriharipriya and K. Arthy[2].

Radhika Bhatt, Nikita Fernandes, ArchanaDhage [3] presents an approach to develop a real-time hand gesture recognition enabling human-computer interaction. It uses webcam and Computer Vision (CV) technology, such as image processing to recognize several hand gestures to interact with computer.

Chee-Hoe Pang, Jer-Vui Lee, Yea-Dat Chuah, Yong-Chai Tan and N. Debnach [4] presents a design of a microcontroller based AC motor controller with heat sensor which varies the speed of a motor in a smart home. The discussion includes the controller based speed control of the motor with respect to the ambient temperature in a smart home environment.

Wlodzimierzkasprak, Arturwilkowski, Karolczapni [5] presents a computer vision system that captures color image sequences, detects and recognizes static hand poses viz., "letters" and interprets this pose sequences in terms of gestures viz., "words".

Piotr Dalka, Andrzej Czyzewski [6] presents a multimodal human-computer interface (HCI) called Lip Mouse, where the user can work on a computer with the help of movements and gestures made with his/her mouth. Webcam is used to capture the face gestures. Face detection is performed using a cascade of boosted classifiers which is Haar-like features. An accurate lip shape is acquired using lip image segmentation with the help of fuzzy clustering.G. R. S. Murthy & R. S. Jadon [7] has also presented the HCI using the same principle.

Premaratne, P, and Nguyen, Q [8] has proposed a model using which TV set top box can be operated using the hand gestures. The webcam is used to capture the image, which is then processed using image processing techniques for gesture recognition based on which the TV set top box is operated.

P. Nagasekhara Reddy [9] explained in his paper to design a real time electronic control system that control the speed of motors kept at remote locations using remote control.T. Yang, Y. Xu, and A. [10] has put forth the idea of implementing the Hidden Markow Model for gesture recognition purpose. He has also explained the advantages of using this technique for recognition purpose.

S. S. Fels and G. E. Hinton [11] has used gloves to sense the gestures. For gesture recognition neural network technique is used. Once the gestures are sensed and recognized the respective commands are played through the speaker.S.F. Ahmed, et al.[12] had also used gloves as its gesture sensing device in his proposed model.

Zhixin Shi Srirangaraj Setlur, Venu Govindaraju [13] has presented an interesting topic related to digital image enhancement using normalization techniques andtheir application to Palm Leaf Manuscripts. Palm leaf manuscripts typically was used for a few centuries but with time the palm leaves degrade and the writing on palm leaves became illegible any more. Image processing techniques can work as a solution to enhance the images of these manuscripts so as get back the written text from these degraded documents. In this paper a set of transformation methods for enhancing digital images of palm leaf manuscripts are proposed.

III.SYSTEM OVERVIEW

The system is using the web camera, gesture processing unit (PC), RF transmitter & receiver, hardware interface comprising of micro- controller, opto-coupler,

TRIAC for controlling the AC motor speed as shown Fig. 2. The webcam is used to capture the hand gestures which are then registered, segmented and feature-extracted as in Fig. 3 for eventual classification to actuate the devices. The setup of the basic components is shown in Figure below. MATLAB is used for real-time data processing and classification while C-language is used for PIC controller coding. Once the user hand gesture matches with a pre-defined command, the command will be issued to the corresponding speed of the AC motor. If an unknown gesture is capture, the system rejects it, notifying the user on the screen. Based on the command sensed the AC motor speed is controlled by varying the duty cycle which is used to trigger the gate of TRIAC.

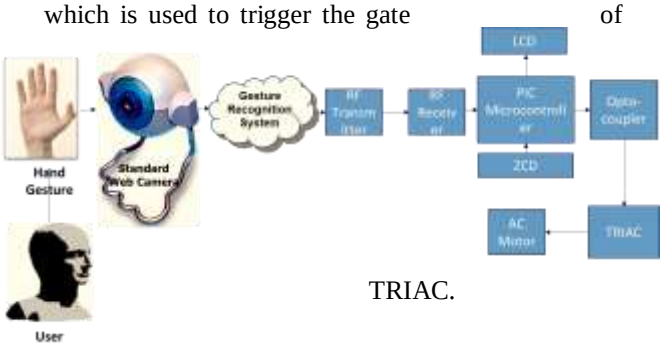


Fig. 2 Block Diagram of System

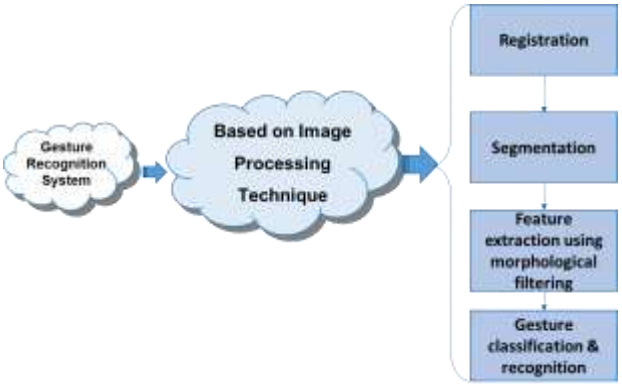


Fig. 3Detailed Gesture Recognition System

IV. IMPLEMENTATION DETAILS FOR GESTURE RECOGNITION

The above block diagram shows the system architecture of the proposed hand gesture recognition system for varying the speed of AC motor. The implementation details are explained as below:

A. Gesture Registration

The real time video stream needs to be processed in order to capture the hand gesture. It's extremely important that the captured image is registered as a hand gesture using segmentation technique. Before going ahead with segmentation the image is first converted from YUV format to RGB format.

B. Segmentation

Image segmentation is referred to the process of partitioning a digital image into N number of parts. The images are segmented with respect to set of pixels or pixels in a region that have some homogeneity criteria such as color, intensity or texture, from which the object is located & identified.With the help of mathematical formulae, Image segmentation splits a digital image f(x, y) into continuous, disconnect & nonempty subsets, using these subsets higher level information can be easily extracted. Practical applications of image segmentation areimage or object identification and recognition, facial recognition, medical image processing, criminal investigation like finger prints, airport security system, satellite images, quality assurance in factories, etc. Due to the importance of the image segmentation, large number of algorithms are available today.

a. Segmentation based on edge detection
b. Threshold Method
c. Region based Segmentation Methods

From the above mentioned techniques threshold method is used here for segmentation purpose.

Image segmentation by using threshold method is not only simple but also very powerful approach for segmenting images based on characteristics of the image.

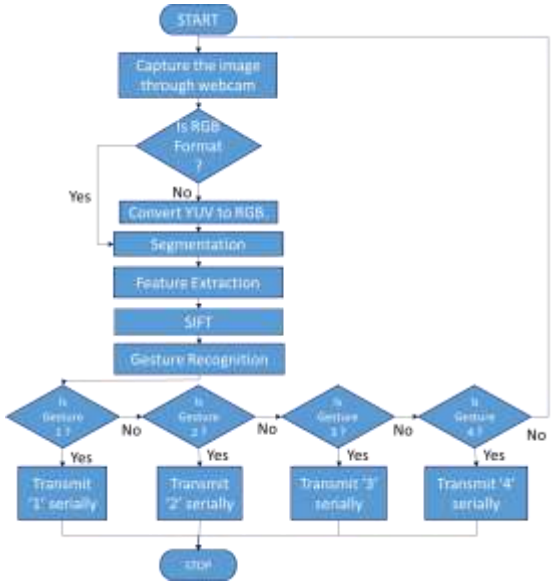


Fig. 4 Flowchart of Gesture recognition

This method is usually used for the contrast combination of object & background any pixel (x, y) for

which f(x, y)>=T is considered to be object while value f(x, y) <T is considered as background. Based on the selection of threshold value, there are two types of threshold method that are in existence:

1) Global Threshold:

In this type of threshold, the value of threshold T depends on the property grey level value of the image. A single threshold value is sufficient to partition the image.

2) Local Threshold:

This method divides an image into several sub regions and then choose various thresholds Ts for each sub region respectively.

For this dissertation global threshold method is used.

Threshold = 0.035

C. Feature Extraction

Features extracted can be locating the fingers and palm, where the hand position is located, and hand centroid estimation. In this method the higher level method is extracted from the image. Below are the parameters extracted by using morphological filtering method.

1. X position of database image's center point
2. Y position of database image's center point
3. X position of input image's center point
4. Y position of input image's center point
5. Num number of key points matched
6. ValidRatio
7. Index number
8. Number of valid key points matched

Based on these information the next step of Gesture recognition is performed.

In order to overcome the errors like rotated, scaled & translated & noisy image SIFT algorithm is used to overcome.

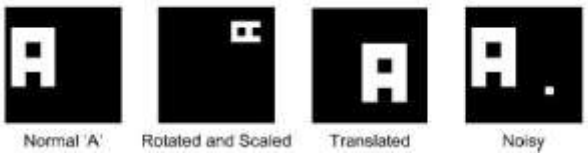


Fig. 5 Rotated, scaled, translated and noisy versions of letter 'A'

D. SIFT (Scale Invariant Feature Transform)

D.Lowe came up with a new algorithm in 2004, Scale Invariant Feature Transform. Distinctive image features from scale invariant keypoints, which extracts keypoints & compute its descriptors. SIFT bundles a feature detector & a feature descriptor. There are mainly 4 steps involved in SIFT algorithm.

Detectors:

1. Find Scale-Space Extrema
2. Keypoint Localization & Filtering – Improve keypoints and throw out bad ones

Descriptors:

3. Orientation Assignment – Remove effects of rotation and scale
4. Create descriptor – Using histograms of orientations

E. Gesture Recognition

In recognition phase the input gesture images are recognized as a gesture which is meaningful depending on the analysis & modeling of gesture.Proper selection of gesture parameters of features affects a lot in recognition phase, and in turn the accuracy of the classification. For example edge detection which is suitable for gesture recognition as it mayresult in a misclassification. Neural network has been widely applied in the field of extracting the hand shape from the background, and for hand gesture recognition.

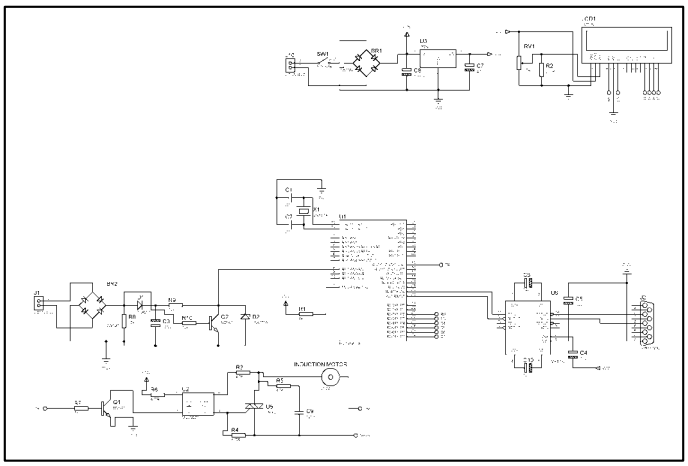


Fig. 6 Circuit Diagram

Once the gesture is recognized, suppose its gesture 1 stored in the database. A byte consisting of number 1, 2, 3, or 4 is transmitted serially by using RF transmitter towards the RF receiver which is connected to the PIC microcontroller. The microcontroller in turn varies the duty cycle accordingly of AC sine wave to give 20%. 35%, 50% or 65% output of half cycle respectively to drive the AC motor through the TRIAC. The circuit diagram of the system architecture is give below as in Fig. 6.

F. CIRCUIT DIAGRAM EXPLANATION

The brain of circuit is the PIC microcontroller. So let us discuss about the controller in brief. In this system PIC (16F877A) controls the activities of LCD & AC Motor. Initially the LCD is made clear then the project name is flashed on the LCD. For the gesture sensed & recognized the respective duty cycle ON time is flashed on the LCD display for eg. "DUTY CYCLE 20ms",

"DUTY CYCLE 35ms", "DUTY CYCLE 50ms", "DUTY CYCLE 65ms". PIC controller also controls the speed of AC motor. The circuit diagram explanation for controller & AC motor interface is as given in the Fig. 7.

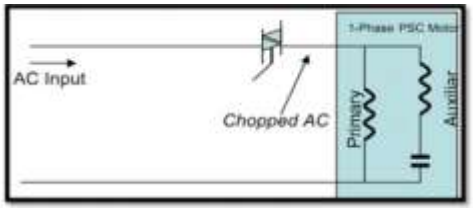


Fig. 7 AC motor speed control hardware of interest

As we know the PIC controller operates with only 5V DC supply voltage while the AC motor works on 230 V supply voltage. There is a vast difference in the supply voltage, thus in case the AC motor if connected directly might damage the controller. So in order to achieve the isolation between these circuits an opto- coupler is used.
A single phase induction motor is the most commonly used AC motor in household appliances. Generally, in all single phase induction motor, the rotor is usually made of a squirrel cage type. Permanent split capacitor (PSC) typed motor comes under the single phase induction motors. It consists of three main parts: main winding in the stator, rotor & starting mechanism. A single phase induction motor doesn't works on a self-starting mechanism. Therefore, the PSC motor has a starting mechanism inbuilt. The starting mechanism provides s start kick for motor to rotate which results in addition of a stator winding. PSC motor consists of a capacitor or centrifugal switch connected in series.

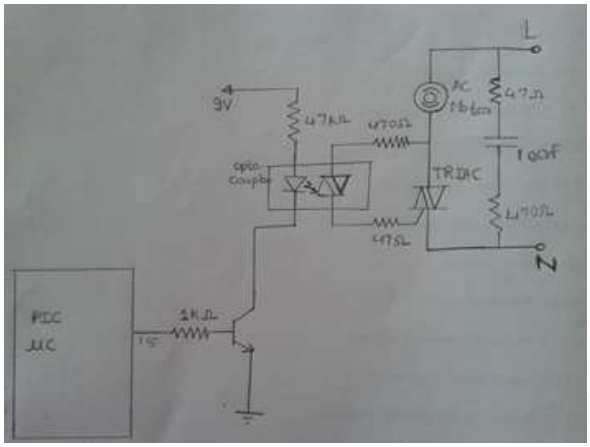


Fig. 8 TRIAC Control of 1-Phase AC Motor

The working principle of a PSC induction motor is explained in extremely simple way. When supply voltage is applied to the motor, the supply voltage in the main winding results in the current flow due to the main winding impedance (Z). At the same time, current in the starting winding may lead or lag the supply voltage (Vs) which depends on the starting mechanism impedance. Interaction between magnetic fields due to main winding and the starting mechanism results in magnetic field rotating in the specific direction depending on the resultant magnetic field. The PSC induction motor is widely used in household appliances, especially the ceiling fan.
Zero crossing detector (ZCD) is used in the circuit in order to detect the zero crossing of AC cycle. This information is needed by the microcontroller in order to vary the duty cycle ON time & OFF time. The crystal frequency of the PIC microcontroller is approximately equal to 16MHz (fosc).This is very high so the time clock frequency is reduced as below, so that it can be easily interpreted.

$$Clock\ frequency = (f_{osc}/4)/4 = (16MHz/4)/4 = 1KHz$$

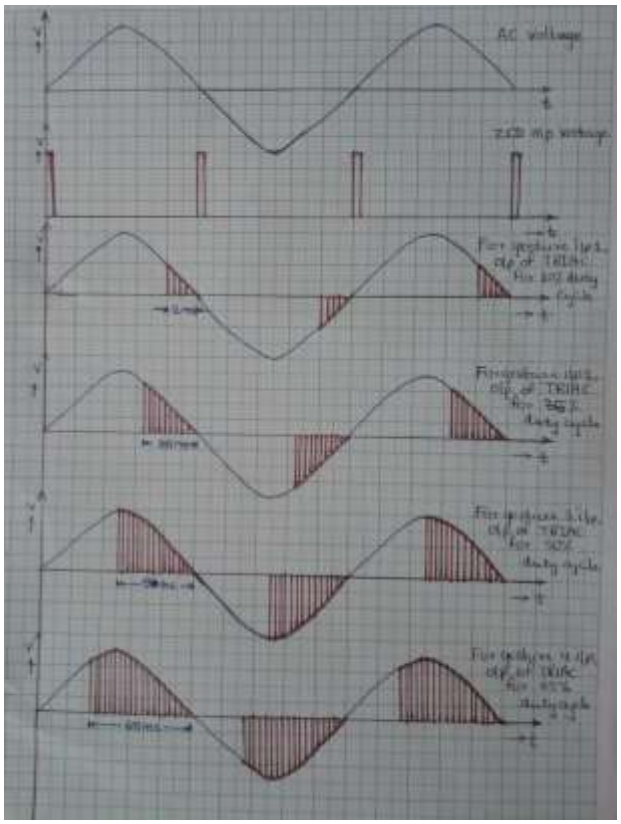
Thus the time period is,

$$Clock\ time = 1\ \mu sec$$

Therefore we conclude that the time to complete one half cycle corresponds to *1µsec*.
Reconnecting the discussion of interpretation of gesture recognition system with microcontroller. After the gesture recognition stage the gesture recognition system transmits a particular byte serially using RF transmitter towards the RF receiver. This byte consists the information about input gesture performed in front of camera corresponding to which the speed of AC motor needs to be varied. Thus the controller selects the duty cycle based on the input gesture acquired. Here the duty cycle yield in the ON time of 1ms, 3ms, 5ms & 7ms corresponding to the speed of 20%, 35%, 50% &65% of the AC Motor. The duty cycle ON time is decided on the basis of below calculations:
As we know the frequency of AC power supply is 50 Hz. So the time period required to complete one full cycle is 20ms. Ultimately the time required to complete a half cycle is equal to 10ms. In order to achieve a speed of 20% we need the 20% ON time of half cycle which is nothing but 1ms. Similarly the 35% ON time corresponds to 3.5ms, 50% corresponds to 5ms &65 % corresponds to 6.5ms respectively.
Now suppose that the input gesture acquired is gesture 1, so '1' is transmitted towards the controller serially by the RF transmitter. Then the controller selects duty cycle with ON time of 1ms to rotate the AC motor with the speed of 20% i.e. 300rpm.Microcontroller operates the AC motor through the TRIAC. When the TRIAC switch is connected between AC power supply & AC motor, the power flow can be controlled by varying the RMS value of the AC voltage. This voltage control is nothing but called an AC voltage controller which is done by using TRIAC. TRIAC is a bidirectional device,

whose gate triggering is controlled with the help of microcontroller through the opto-coupler. As seen from the circuit diagram, the TRIAC in series with AC motor & snubber circuit complete the loop. If the microcontroller triggers the gate of TRIAC the circuit is complete else the circuit remains open. Symmetric angle control method is used to drive the AC motor. The advantage of this method is, it reduces the mechanical variations due to abrupt changes in firing angle. Now, when the microcontroller triggers the gate of TRIAC the AC motor runs & thus the variation in speed is observed accordingly with the change in duty cycle. The graph as shown below in graph 1 gives the clear idea about the output of TRIAC obtained for different duty cycles.

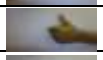
Graph 1 Output signal obtained at the TRIAC which is given as input to the AC Motor



V RESULTS &DISCUSSION

A laptop camera is used for capturing the hand gesture. Background used here is only uniform. Due to non-uniform background, erroneous results were faced. The user was showing the gestures as shown in the table 1 below. According to the gesture performed the software algorithm resulted with the feature extraction & expected gesture recognition. This result was forwarded towards the PIC microcontroller serially by using RF transmitter & receiver. According to the gesture performed the motor speed is varied as per the requirement as shown in the table 1 below.

Table 1. Results

Gesture Input	On Time Period in ms	AC motor speed in %	AC motor speed in rpm
	2ms	20%	300 rpm
	3.5ms	35%	525 rpm
	5ms	50%	750 rpm
	6.5ms	65%	975 rpm

VICONCLUSION

This dissertation consists a set of gestures that are distinct from each other yet easy to recognize by the system. This set of hand gestures is enough for any consumer electronic control system to be actuated. The software interface using a MATLAB produces unique speed regulator mapping ability such that the 'Speed' function of a ceiling fan can be mapped to the 'Volume' in TV using the gesture recognition interface.

The main aim of this dissertation is to make a system which controls the fan speed and lights remotely, for physically impaired people without the use of complex form of inputs. Just the gestures will be sufficient to operate the household electronic appliances.

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