

University of Florida EEL5666
Intelligent Machine Design Lab

AJ-21

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Abstract

The blackjack dealer is, as the name suggests, an autonomous card dealer specializing in the game of blackjack. Using its own deck of cards the robot can take bets, deal hands, recognize which hands are winners and losers, and pay the player (or house) appropriately.

Executive Summary

AJ-21 is designed to function as a completely autonomous blackjack dealer. AJ has four main behavioral modes. First, he collects bets. Then he deals everyone a hand. Third, he plays each hand with the player and then his own. Finally, he calculates payouts and adjusts players' accounts. Every time AJ needs to interact with a certain player he moves his arm to that player. During movement if anyone or anything touches AJ's bump sensors he stops and asks for this problem to be fixed. Every second after a bump sensor is hit AJ checks to see if the sensor is still being triggered. If not, he continues to play. AJ also always knows where he is on the table since there is a lower sensor that gets tripped by adjustable hooks mounted into the table. The hooks were made adjustable on purpose to accommodate for wear and tear on AJ that might require tweaking of the system (warping of the wooden base for example). All player accounts are stored inside computer memory so there is no need for the use of betting chips. Future models of AJ may include a bill collector and receipt printer for further betting versatility.

Introduction

Are you a casino owner and are tired of your dealers calling in sick, showing up late, or perhaps even cheating with your patrons? Or perhaps you are blackjack player who wants to practice at home. Are you someone interested in gambling but not sure you want to risk losing a lot of money at a casino just to learn how to play the games before having a decent chance at winning? Or maybe you just like blackjack and think it would be neat to see a robot play with you. If you are any of the people mentioned above then AJ-21 (called “AJ” for short) is perfect for you.

AJ is a completely independently functioning blackjack dealer that can be used in a casino or at home. The following report describes the tasks AJ can perform as well as how these tasks are accomplished.

Integrated System

At the core of the AJ-21 is the Motorola 68HC12 Micro-controller mounted on the UF-MicroP development board. This is then interfaced with the following devices.

- 2 movement servos for mobility on the table
- 1 dealer servo for the dealing of cards
- 1 LCD for feedback
- 2 bump sensors for obstacle avoidance
- 1 keypad for user input
- 1 KaneScan barcode scanner for card recognition

The two movement servos connect to wheels attached to the arm of the robot. One is completely perpendicular to the arm and acts as the drive while the other is offset to act as the steering.

The bump sensors are attached to the front and back ends of the robot and will let the micro-controller know when the robot has run into something.

The barcode scanner is used to recognize the actual card values. Each card has a barcode on it that is read as soon as the card is dealt out of the dealer shoe.

The LCD not only serves as a means of prompting players for bets or what they want to do on their turn, but also sends debugging feedback to the users in case of apparent misconduct.

Platform

The platform is a large board approximately 2.5 ft by 5.5 ft and is covered by official casino blackjack felt. At the players' end of the board there are 5 switches. Each switch allows for the player to play the current round (switch on) or sit out (switch off). The main part AJ is his arm. This is mounted to a support beam that runs directly up the center of the board on the bottom side. At the end of the beam there is a large metal screw that holds the main arm in place. The main arm has a hole at one end (which rests on the large screw). At the top of the arm near the hole is a square platform where the HC12 board resides. Seven inches further down the arm is the battery pack for the servos. Four inches from the battery pack is the dealer shoe. The dealer shoe is mounted on a beam almost perpendicular to the main arm. The beam is slightly offset to allow for steering (as the steering servo is mounted directly to this beam) but the shoe itself is completely perpendicular to the dealer arm. On top of the dealer shoe are the barcode scanner and the dealer servo. The dealer servo has a large rubber wheel attached to it with enough friction to deal out the cards. The barcode scanner is attached to the dealer shoe via Velcro and scans each card just before it falls to the table. Finally, at the end of the main arm are the LCD and the keypad.

Actuation

The AJ-21 moves via two servos. One servo (used for drive) is attached at the end of the main arm directly under the keypad. By placing it as far as possible from the pivot point (the large screw at the other end of the arm) AJ maximizes the torque obtained from the servo movement. The other servo is mounted below a slightly offset beam extending out from the main arm. This servo is used for steering.

Sensors

Sensor : Locale sensor

Part # : None

Vendor: Electronics Plus

Qty. : 1

Desc. : This is actually a bump sensor mounted on the underside of AJ's main arm. It generates an interrupt when clicked and updates the variable which keeps track of the location on the table. The table has 12 adjustable hooks on it in key locations such as player's position or dealer's hand.

Sensor : Bump sensor

Part # : None

Vendor: Electronics Plus

Qty. : 2

Desc. : A bump sensor will be mounted on the front and back of the platform. These consist of a simple switch that when connected tell the micro-controller AJ is making contact with another object. When such a signal is sent to AJ, he alerts the players that his path is blocked and will not continue the game until the obstacle is removed.

Sensor : KaneScan Barcode Scanner

Part # : 02001291

Qty. : 1

Desc. : The KaneScan barcode scanner is an affordable (\$60) highly accurate (4 mils) barcode scanner. Each card in AJ's deck has a barcode on the top corresponding to the value of the card in blackjack. Aces are coded with the number 1 and are handled by the software as aces can be 1 or 11. The barcode scanner is mounted atop the dealer shoe and scans each card as it is dealt to players or the dealer. The scanner is interfaced via RS-232 port. For more information as to how this is accomplished please refer to the special sensor report submitted with AJ.

Behaviors

- Bet Phase:** Players are given 20 credits to start off with. Each round AJ moves to every player who has opted to play and asks how much he or she wishes to wager on the upcoming hand. Valid bets are zero through nine credits.
- Deal Phase:** In this phase AJ knows how many players are “in” and “out” and deals the cards out in proper blackjack order. That is, each player gets one card and then the dealer. Then each player gets a second card followed again by the dealer.
- Play Phase:** During this time AJ will respond to command such as “hit”, “stay”, “split”, or “double down”. All commands are input via the keypad. During play AJ moves the arm to the current player thus placing the LCD and the keypad in front of the player. All instructions are given via the LCD and player action is read from the keypad. If at any time a player receives 21 or busts (both cases where the current player’s turn is over) AJ automatically moves to the next player.
- Pay Phase:** At the end of the round AJ will add or subtract the players’ wager from his account depending if the player won or lost.

Conclusion

The AJ-21 is a fully functional blackjack dealer that can be used at home or in the casino. It can be a tool for learning the game, playing it in for entertainment, or as a full-fledged blackjack dealer. When I started the project I was definitely aiming way too high. I wanted to be able to flip cards over, use image processing for card recognition, use a CMU-Cam for color recognition (when I thought I would collect bets through the use of chips), and wanted to possibly have AJ talk. This was all way too much. I'm actually happy I accomplished what I did.

There were some major setbacks that made it so the project was harder than it should have been. First being, the first two boards I bought weren't ideal for the project or they plain didn't work. Also, I realize for my first robot project I took on a rather difficult task. A blackjack dealer is a lot more complicated than I thought it would be.

If I could start the project over I would number 1 set out using the HC12 right from the start. This is a board I know really well and in building AJ I proved it can compete with other more expensive boards. One of the huge advantages to the HC12 is the fact that it has eight, 16-bit timers on board. This more than makes up for the lack of PWM support. PWM is easily simulated through the use of these timers.

If I could make any enhancements to AJ I think it would be neat to add a bill collect and receipt printer to him. This was instead of being given 20 credits to play with players would be required to insert actual money (1 dollar per credit for example) to play. When play was over, a player's account balance could be printed out via receipt where he could go to a claims desk in a casino to collect his money.

Also, knowing what I know now I would have never tried to make AJ mobile. This was my original design but just complicated things way too much. Kevin Phillipson's idea of mounting the robot to a table really saved a lot of time.

Code Snippets

The following code is how the barcode scanner reads values in to the micro-controller.

```
*****
* SUBROUTINE: IN_CHAR *
* *
* Reads two bytes in from barcode scanner *
* and stores them at BARCODEDATA *
*****
IN_CHAR      PSHA
              PSHX
              PSHY
              PSHB

              LDY   #BARCODEDATA
              LDAB  #02

              JSR   STARTDEAL    ; start dealing cards

READAGAIN    LDAA  LINESR        ; Check status reg (bit 0)
              ANDA  #BIT0        ; Check if receive buffer full

              BEQ   READAGAIN    ; Wait until data present

              JSR   STOPDEAL     ; stop dealing cards

              LDAA  #$00         ; clear LEDs with each card dealt
              STAA  $2000

              LDAA  RBR          ; load A register with the data
              ANDA  #$0F         ; clear upper nibble
              BNE   CHECKACE     ; if value is non-zero, check for ace

              ADDA  #10          ; add 10 to a 0

CHECKACE     CMPA  #1
              BNE   STOREIT      ; if not an ace, store the value

              ADDA  #10
```

```

PSHB                ; temp. save B onto stack
PSHA                ; temp. save A onto stack
PSHX                ; save X

LDAB #14            ; ACEAS11 flag is always 14
SUBB NUMCARSDATA   ; bytes into player stats
ABX                 ; but X points to the last card
                   ; here we subtract player's total
LDAA #$AA          ; number of cards from 14, add
STAA 0,X           ; the result to X and store

PULX                ; restore X
PULA                ; restore A
PULB                ; restore B

STOREIT            STAA 0,Y                ; store data to Barcode
location

INY                 ; increment Y
DECB                ; decrement B
BNE READAGAIN      ; read next byte

PULB
PULY
PULX
PULA
RTS                 ; Return from subroutine

```

```

*****
* SUBROUTINE: DEALCARD *
* * *
* Deals a card and records data to the *
* appropriate memory location. *
* * *
* NOTE: This sub requires that Y points *
* the LCD prompt and X points to *
* the storage location. *
*****

```

```

DEALCARD PSHA
          PSXB

```

```

LDAA #$00          ; clear LCD
STAA LCD_CTRL      ; ...
JSR LCD_DELAY      ; ...

LDAA #$01          ; ...
STAA LCD_CTRL      ; ...
JSR LCD_DELAY      ; end of clear LCD

JSR OUT_LCD

JSR IN_CHAR

JSR BC_OUT_LCD

LDAB BARCODEDATA   ; store card to memory
STAB 0,X           ; location

PULB
PULA
RTS

```

This code section shows how to use IRQ with multiple devices. Every device is tied to a port pin and when an IRQ is fired those pins are polled. Also, OC4 (output compare timer 4) is used to temporarily disable IRQ interrupts. This gives AJ time to get his arm over the hooks on the table. IRQ has to be disabled since IC/OC interrupts take a lower priority than IRQ. Leaving IRQ enabled turns off the wheels so AJ gets stuck on a hook.

```

*****
*      ISR:  IRQ      *
*****

IRQ_ISR      BCLR  INTCR  BIT6    ; disable IRQ

              BCLR  TCTL1 OM4
              BSET  TCTL1 OL4    ; OM4:OL4=01 (toggle)

              BCLR  TFLG1 INV_C4F ; clear OC4 flag
              BSET  TMSK1 C4I    ; enable OC4 interrupt

              LDAA  #20
              STAA  IRQTIMER

```

```
LDAA DATADLC
ANDA  #%01000000 ; check for object collision (rear)
BNE   COLLISION

LDAA DATADLC
ANDA  #%00100000 ; check for object collision (front)
BEQ   COLLISION

TABLETABHIT LDAA #1
            STAA TABHIT

            JSR  CLEARLCD
            LDY  #LCDTABHIT
            JSR  OUT_LCD
            BRA  EXIT_IRQ

COLLISION  BCLR TCTL2 OL2 ; OM2:OL2=00 (disconnects OC2 )
            BCLR TCTL2 OM2 ; this stops servo movement

            BCLR TCTL2 OL3 ; OM3:OL3=00 (disconnects OC3 )
            BCLR TCTL2 OM3 ; this stops servo movement

            JSR  CLEARLCD
            LDY  #OBJECTHIT
            JSR  OUT_LCD
            JSR  PAUSE

EXIT_IRQ   RTI
```

Acknowledgements

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First, Jeffery Putney. Jeff lent me countless supplies from saws to wire-wrap and made so many things possible. I couldn't have done IMDL without him. I also would like to give him credit for the positioning switch idea. When I was thinking I had to have a switch at every player's position in order for AJ to know where he was on the table it was Jeff who suggested mounting a switch on the arm somewhere and having things on the table hit it.

Second, Kevin Phillipson. Kevin built UF's first automated blackjack dealer and gave me countless ideas as to how to accomplish building my own. My platform design is largely modeled off his. The barcode scanner idea was also his. He also gave me his cell phone number so I could call him at any time with questions about how to accomplish any given task.

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