Title: PLAYING CARD IMAGING WITH THROUGH-THE-CARD VIEWING TECHNOLOGY

Abstract: A method of reading suit and rank of playing cards is enabled on a system for controlled provision of image content of faces of a playing card that has: a) a support surface for playing cards; b) a source of infrared radiation; c) an infrared sensitive camera; and d) a processor. The infrared sensitive camera positioned to capture infrared radiation transmitted through the playing cards and transmit information based on the captured radiation to the processor; and the processor configured to provide suit and rank information of a playing card through which the infrared radiation was transmitted. A system for determining value of wagers, payouts and cash-ins by sensing weight of wagering chips is also provided.
PLAYING CARD IMAGING TECHNOLOGY WITH THROUGH-THE-CARD VIEWING TECHNOLOGY

RELATED APPLICATIONS


BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of gaming, particularly card games, and even more particularly to the field of card gaming where security and management information relating to availability of card suit and rank and wagers placed by players is important.

2. Background of the Art

Digital camera sensors are inherently sensitive to infrared light, which would interfere with the normal photography by confusing the autofocus calculations or softening the image (because infrared light is focused differently from visible light), or oversaturating the red channel. Thus, to improve image quality and protect privacy, many digital cameras employ infrared blockers. Depending on the subject matter, infrared photography may not be practical with these cameras because the exposure times become overly long, often in the range of 30 seconds, creating noise and motion blur in the final image. Some lenses will also show a 'hot spot' in the center of the image as their coatings are optimized for visible light and not for IR.

An alternative method of DSLR (digital single lens reflex) infrared photography is to remove the infrared blocker in front of the sensor and replace it with a filter that removes visible light. This filter is behind the mirror, so the camera can be used normally - handheld, normal shutter speeds, normal composition through the viewfinder, and focus, all work like a normal camera. Metering works but is not always accurate because of the difference between visible and infrared reflection. When the IR blocker is removed, many lenses which did display a hotspot cease to do so, and become perfectly usable for infrared photography. Additionally,
because the red, green and blue micro-filters remain and have transmissions not only in their respective color but also in the infrared, enhanced infrared color may be recorded.

While it is common to use a filter that blocks almost all visible light, the wavelength sensitivity of a digital camera without internal infrared blocking is such that a variety of artistic results can be obtained with more conventional filtration. For example, a very dark neutral density filter can be used (such as the Hoya ND400) which passes a very small amount of visible light compared to the near-infrared it allows through. Wider filtration permits an SLR viewfinder to be used and also passes more varied color information to the sensor without necessarily reducing the Wood effect. Wider filtration is however likely to reduce other infrared artifacts such as haze penetration and darkened skies. This technique mirrors the methods used by infrared film photographers where black-and-white infrared film was often used with a deep red filter rather than a visually opaque one.

Near infrared light consists of light just beyond visible red light (wavelengths greater than 700, greater than 750 or greater than 780nm). Contrary to popular thought, near infrared photography does not allow the recording of thermal radiation (heat). Far-infrared thermal imaging requires more specialized equipment, and is not the subject of this tutorial. Infrared images exhibit a few distinct effects that give them an exotic, antique look. Plant life looks completely white because it reflects almost all infrared light (because of this effect, infrared photography is commonly used in aerial photography to analyze crop yields, pest control, etc.) The sky is a stark black because no infrared light is scattered. Human skin tends to look pale and ghostly.

Infrared photography has been around for at least 70 years, but until recently has not been easily accessible to those not versed in traditional photographic processes. Since the charge-coupled devices (CCDs) used in digital cameras and camcorders are sensitive to near-infrared light, they can be used to capture infrared photos. With a filter that blocks out all visible light (also frequently called a "cold mirror" filter), most modern digital cameras and camcorders can capture photographs in infrared. In addition, they have LCD screens, which can be used to preview the resulting image in real-time, a tool unavailable in traditional photography without using filters that allow some visible (red) light through.
Remote sensing and thermographic cameras are sensitive to longer wavelengths of infrared. They may be multispectral and use a variety of technologies which may not resemble common camera or filter designs. Cameras sensitive to longer infrared wavelengths including those used in infrared astronomy often require cooling to reduce thermally induced dark currents in the sensor. Lower cost uncooled thermographic digital cameras operate in the Long Wave infrared band. These cameras are generally used for building inspection or preventative maintenance but can be used for artistic pursuits as well.

In the gaming industry, more and more technology is being used to combine traditional physical gaming elements (random event generators such as playing cards, dice and roulette wheels) with electronic systems that enable all aspects of the wagering games. For example, not only are wagers accepted and resolved through electronic systems, but physical event outcomes are electronically determined (read and analyzed) and this physical event is used in determining game outcomes. Of all the systems, the combination of electronic systems with playing card wagering games has been the most difficult, as the cards may vary in readability during the game (face-up versus face-down) and the images on the playing cards vary between decks. Many attempts have been made to effectively and accurately read playing cards during wagering games.

U.S. Patent No. 6,403,908 (Stardust) discloses an automated method and apparatus for sequencing and/or inspecting decks of playing. The method and apparatus utilizes pattern recognition technology or other image comparison technology to compare one or more images of a card with memory containing known good images of a complete deck of playing cards to identify each card as it passes through the apparatus. Once the card is identified, it is temporarily stored in a location corresponding to or identified according to its position in a properly sequenced deck of playing cards. Once a full set of cards has been stored, the cards are released in proper sequence to a completed deck hopper. The method and apparatus also includes an operator interface capable of displaying a magnified version of potential defects or problem areas contained on a card which may then be viewed by the operator on a monitor or screen and either accepted or rejected via operator input. The present invention is also capable of providing an overall wear rating for each deck of playing cards. In order to certify that deck of playing cards is good and acceptable for play, the casino must ascertain that: (1) there is one and only one of each type (i.e. by suit and rank) of playing card in the deck of playing cards, (2) all of the backs of the playing cards contained in the deck are of the same
color, (3) there are no defective playing cards (i.e. torn or cracked cards, cards with dimples or fingernail marks, cards with missing print or cards with spots), and (4) there are no boxed cards (cards facing backwards, etc.) contained in the deck of playing cards. Imaging cameras are used to obtain one or more images of each side of the card after the double card check is made. A low resolution is made of the front to determine suit and rank and back to determine color of the card. Generally, high resolution imaging is utilized to determine fine marks and problems. If the system is not in an inspect mode, it is possible to use the cameras simply to image a corner of the card, since the information necessary as to color and suit and rank is available in this portion of each card.

U.S. Patent No. 5,941,769 (Order) discloses that in professional use in table games of chance with playing cards are provided which will register and evaluate all phases of the run of the game automatically. This is achieved by a card shoe with an integrated device for recognition of the value of the drawn cards (optical recognition device and mirroring into a CCD-image converter); photodiodes arranged under the table cloth to register separately the casino light passing through each area for placing the gaming chips and areas for placing the playing cards in dependence of the arrangement or movement of the chips and playing cards on the mentioned areas; a device for automatic recognition of each bet (scanner or a RFID-system comprising a S/R station and gaming objects with integrated transponder); an EDP program created in accordance with the gaming rules to evaluate and store all data transmitted from the functional devices to the computer; and a monitor to display the run of the game and players' wins.

U.S. Patent No. 5,770,533 (Franchi) describes a casino operating system for controlling the flow of funds and monitoring gambling activities in a casino or a gaming establishment utilizing a network of computers, including a central computer and individual game computers. Each player receives an encoded betting card from the cashier. At the games, each player position is equipped with a control panel including a card reader into which the betting card is inserted. The control panel also includes an electronic screen and keyboard. From the control panel, the player may place a bet and perform all options available to the player in the particular game. The system records the hands dealt to each player and the winner, and credits or debits the player's betting card accordingly. In an alternative embodiment, the casino operating system allows the players to use chips to place bets instead of the above-described betting card. The chips are marked or encoded so that they can be
counted once final bets have been placed to determine the amount of each player's bet. In games requiring the placement of bets in certain positions on the gaming table, each player may be provided with a betting marker used to indicate the position of his bets on the table, a touch-sensitive screen maybe used whereby bets are placed by touching the desired position on the screen, or a two-way remote control console for placing bets. The casino operating system is an open architecture system adaptable to accommodate the differing needs of each casino.

U.S. Patent No. 4,531,187 (Uhland) describes a system for monitoring the play at gambling games is disclosed. The preferred embodiment comprises a system for monitoring the play at blackjack as that game is played in casinos. The system typically will comprise video monitor means for generating a digital representation of the bets made by the players and of the cards dealt to the players and to the dealer, so that an output can be generated indicating whether the correct payouts are made and bets collected. An alarm signal is generated if an error is made in the play of the game. An alarm signal may also be generated if the long-term statistics of the game indicate that the odds ordinarily applicable to the game have been departed from over a period of time.

U.S. Patent No. 8,221,244 (French) describes methods and systems for intelligent tracking and/or play and/or management of card gaming use an intelligent card distribution or holding device with detectors for determining the value and unique identity of individual cards and for recording card play. Playing cards are equipped with a read/write data storage connected to a transponder and/or incorporated into electromagnetic writable particles or smart particles (smart dust). A system of the invention records various game play events on the playing cards themselves during game play and optionally also in a database on the system. In specific embodiments, the principal scanning and writing elements and electronic and optical interfaces are embodied into a hand-held card holder (HHCH). The system can scan playing cards, scan gaming chips, indicate a player's win/loss/draw, increase or decrease player betting positions, and compute awards to players based on their playing activity.

U.S. Patent No. 7,967,672 (Shigeta) describes a card reading device that comprises a rail for guiding a card; card sensors for detecting a passing card which is slid by hand and guided by the rail, which are placed in a card sliding direction with a certain gap; and reading sensors for reading code attached to the card, which are placed between the two card sensors in the
card sliding direction. The card have the cord which is printed in UV-luminous ink on the
card, and the code comprises at least two code rows which are placed across the card sliding
direction with a certain gap. The two reading sensors are placed in positions which
 correspond to the gap of the two code rows, and the card sensors output signal for detecting a
position of the passing card.

U.S. Patent No. 6,629,894 (Purton) describes a card inspection device that includes a first
loading area adapted to receive one or more decks of playing cards. A drive roller is located
adjacent the loading area and positioned to impinge on a card if a card were present in the
loading area. The loading area has an exit through which cards are urged, one at a time, by a
feed roller. A transport path extends from the loading area exit to a card accumulation area.
The transport path is further defined by two pairs of transport rollers, one roller of each pair
above the transport path and one roller of each pair below the transport path. A camera is
located between the two pairs of transport rollers, and a processor governs the operation of a
digital camera and the rollers. A printer produces a record of the device's operation based on
an output of the processor, and a portion of the transport path is illuminated by one or more
blue LEDs. Preferably a low temperature source of light is located so as to illuminate the
area of the card that is being scanned.

The computer or signal processor compiles the scan data and reports and records the result of
the scans of all of the cards in the one or more decks. FIG. 15 illustrates how a card transport
path 400 may be subdivided by locating baffles above or below the roller pairs in order to
create distinct zones. Each zone may have a particular form of detector, polarimeter, diode or
line scanner as well as a particular light source or lighting method. By locating sensors both
above and below the transport path, both sides of the card may be examined simultaneously.
This provides the opportunity to detect suit and value of an inverted card as well as increasing
the sophistication with which tampering may be detected. Polarized light may be used to
detect certain forms of tampering. In such a case, the polarity of the light source may be
rotated during the detection process. Similarly, a non-polarized source may be moved during
the detection process to create a moving shadow. One or more light sources may be movable
or set to illuminate off-axis so that certain forms of scratches and pinholes may be more
easily detected by their shadow or reflectance. It is contemplated that both color and
monochrome imaging methods may provide useful information about the condition of the
cards. Similarly both digital and analogue sensing methods are seen to have independent utility and functionality with regard to both suit and value detection as well as the detection of faults, wear and tampering. It should be noted that the compartmentalization of the card transport path into distinct lighting and sensing zones may be applied to any embodiment disclosed.

Published U.S. Patent Application Document No. 20050242500 (Downs III) describes a sensing system for determining the rank and suit of playing cards. The system includes a sensing module capable of reading a line of data from a printed image, a position sensor and a hardware component that combines the signals from the sensing module and position sensor, converts the signal to binary values and compares the converted signal to stored signals. The comparisons are correlated to identify card rank and Suit. The system can be used in a playing card delivery shoe used to control the game of baccarat. The shoe may be a customary dealing shoe equipped with a sensing module, or may be a mechanized shoe. The mechanized shoe may comprise a) an area for receiving a first set of playing cards useful in the play of the casino table card game of baccarat; b) first card mover that moves playing cards from the first set to a playing card staging area wherein at least one playing card is staged in an order by which playing cards are removed from the first set of and moved to the playing card staging area; c) second playing card mover that moves playing cards from the playing card staging area to a delivery area wherein playing cards removed from the staging area to the delivery shoe are moved in the same order by which playing cards were removed from the first set of playing cards and moved to the playing card staging area; and d) playing card reading sensors that read at least one playing card value of each playing card separately after each playing card has been removed from the area for receiving the first set of playing cards and before removal from the playing card delivery area One exemplary sensing system is a CIS line scanning system with an associated card position sensor and a FPGA hardware element.

Published U.S. Patent Application Document No. 20070018389 (Downs III) describes a method and an apparatus determines at least one of rank or suit of a playing card. The apparatus has at least one two-dimensional complementary metal oxide semiconductor imaging system that provides a signal when playing cards are moved over the system. The signal is a series of gray scale values that are converted into binary values. The sensed data is
transmitted to a hardware component that identifies at least one of rank and suit to an external
data storage device.

Published U.S. Patent Application Document No. 20070102879 (Stasson) describes a playing
card shuffling device that has a visual display in information communication with the playing
card shuffling device. At least one processor is programmed to provide displayable
information to the visual display indicative of an amount of time remaining or time expired in
a procedure performed by the shuffling device. FIG. 1 shows a partial perspective view of
the top surface of a first shuffling and card verification apparatus according to a practice of
the invention. In this example of the invention, the device randomizes and/or verifies one or
two decks of cards. The shuffling apparatus has a card accepting/receiving area that is
preferably provided with a stationary lower support surface that slopes downwardly from the
nearest outer side of the shuffling and verifying apparatus. A depression is provided in that
nearest outer side to facilitate an operator's ability to place or remove cards into the card
accepting/receiving area. The top surface of the shuffling and verifying apparatus is provided
with a visual display (e.g., LED, liquid crystal, micro monitor, semiconductor display, multi-
segment display, etc.), and a series of buttons, touch pads, lights and/or displays. These
elements on the top surface of the shuffling and verifying device may act to indicate power
availability (on/off), shuffler state (jam, active shuffling, completed shuffling cycle,
insufficient numbers of cards, missing cards, sufficient numbers of cards, complete deck(s),
damaged or marked cards, entry functions for the dealer to identify the number of players, the
number of cards per hand, access to fixed programming for various games, the number of
decks being shuffled, card calibration information, mode of operation (i.e. shuffling,
verifying or both shuffling and verifying) and the like), or other information useful to the
operator or casino. Among the non-limiting examples of these techniques are 1) a sensor so
that when a pre-selected portion of the card (e.g., leading edge, trailing edge, and mark or
feature on the card) passes a reading device, such as an optical reader, the bottom pick-off
roller is directed to disengage, revolve freely, or withdraw from the bottom of the set of
cards; 2) the first set of nip rollers or off-set rollers may have a surface speed that is greater
than the surface speed of the bottom pick-off roller, so that engagement of a card applies
tension against the bottom pick-off roller and the roller disengages with free rolling gearing,
so that no forward moving forces are applied to the first card or any other card exposed upon
movement of the first card; 3) a timing sequence so that, upon movement of the bottom pick-
off roller for a defined period of time or for a defined amount of rotation (which correlates into a defined distance of movement of the first card), the bottom pick-off roller disengages, withdraws, or otherwise stops applying forces against the first card and thereby avoids applying forces against any other cards exposed by movement of the first card from the card accepting/receiving area 106 and 4) providing a stepped surface (not shown) between pick-off roller and off-set rollers 146 that contacts a leading edge of each card and will cause a card to be held up or retained in the event that more than one card feeds at a time.

Other disclosures have also contemplated optically reading of playing cards. For example, U.S. Patent Nos. 6,582,301; 6,039,650; and 5,722,893 to Hill et al. describes a shoe with a card scanner, which optically scans a playing card as the card moves out of shoe. The card suit and value is then recognized by a neural-network algorithm. Other disclosures have also attempted to track cards by use of card shoes that optically recognize the cards as they are drawn from the shoe. For example, U.S. Patent Nos. 5,941,769 and 6,460,848 disclose a card shoe with an optical device that deflects and transmits a reflected image of the card value imprint from the drawn playing card to a CCD image converter. Still other disclosures have attempted to combine detection of playing cards optically and gambling chips by some means. For example, U.S. Patent Nos. 5,605,334; 6,093,103 and 6,1 17,012 to McCrea et al., disclose a game table system for monitoring each hand in a progressive live card game. The system comprises a shoe that optically detects the value and suit of each card, a game bet sensor to detect the presence or absence of a bet, a card sensor located at each player position to detect the presence or absence of a playing card, and a game control. The game control receives information on the presence or absence of a bet or playing card to ensure a bet is placed before the playing card is dealt.

Published U.S. Patent Application Document No. 20100019449 (Downs III) describes how a playing card delivery shoe is used in the play of the casino table card game of baccarat or blackjack or any game where cards are pulled one at a time from the shoe. The apparatus comprises a reader or an imager that scans lines bisecting the image at spaced intervals. The scanning occurs on playing cards in at least the region where suit and rank symbols are provided. The scanner output is a series of voltages that are converted to binary information. This binary information is compared to stored binary information to determine rank and suit. The upper surface of the output end of the shoe contains a partial barrier for cards being
scanned. The partial barrier has an elevated surface and limits a size of a pathway so that
only one card can be removed at a time.

U.S. Patent No. 6,460,848 (SOLTYS) describes a system that automatically monitors playing
and wagering of a game, including the gaming habits of players and the performance of
employees. A card deck reader automatically reads a symbol from each card in a deck of
cards before a first one of the cards is removed. The symbol identifies a respective rank and
suit of the card. There are numerous other related patents including U.S. Pat. Nos. 6,712,696;
6,688,979; 6,685,568; 6,663,490; 6,652,379; 6,638,161; 6,595,857; 6,579,181; 6,579,180;
6,533,662; 6,533,276; 6,530,837; 6,530,836; 6,527,271; 6,520,857; 6,517,436; and
6,517,435.

Other systems known to be available for reading of card symbols (e.g., suits and rank)
include at least WIPO Published Application WO/2000/051076 (Dolphin); Published U.S.
Patent Application Documents No. 2011020175; 2010061342; 20040026636; and U.S. Patent
Nos. 6,726,205; 6,527,191; 6,533,276 and 8,020,869.

All of the references cited herein are incorporated by reference in their entirety to assist in
providing enabling background for systems and technology and methods.

SUMMARY OF THE INVENTION

A method of reading suit and rank of playing cards and detect and/or even read chips
on the table is enabled on a system for controlled provision of image content of faces of a
playing card that has:

a) a support surface for playing cards;
b) a source of near-infrared or infrared radiation;
c) an infrared sensitive camera (sensitive to the radiation from the source);
and
d) a processor.

The infrared sensitive camera positioned to capture infrared radiation transmitted through the
playing cards and transmit information based on the captured radiation to the processor; and
the processor configured to provide suit and rank information of a playing card through
which the infrared radiation was transmitted. The use of a cut-off filter in the camera that
excludes or reduces non-useful ranges of wavelengths (e.g., visible and/or UV) and allows more useful (infrared) ranges of wavelengths sharpens images or card values for viewing. The camera and radiation transmitter are generally on opposite sides of the playing cards. Using a prism or mirror or other reflective element, the camera and radiation emitter may be on the same side of the playing card. Weighing chips and IR-see-through imaging can provide wager valuation at each wagering position.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1 shows a perspective view of a playing card delivery shoe useful within the scope of the present technology in combination with an overhead camera.

Fig. 2 shows a gaming table layout with through-card reading capability on the table top itself in combination with an overhead camera.

Fig. 3 shows a perspective view of a delivery shoe with novel card reading capability using through-the-card imaging and refraction/reflection technology.

Fig. 4 shows a side view of a gaming table, under-table lighting system and camera system enabling practice of one aspect of the present technology.

Fig. 5 shows a series of images of gaming chips that have been imaged by penetrating radiation.

Fig. 6 shows a side view of a gaming table, under-table lighting system and camera system, and weighing system for chips enabling practice of one aspect of the present technology.

DETAILED DESCRIPTION OF THE INVENTION

The present technology includes a system and method. The method reads information from a playing card while an image face of the playing card is hidden by a visible light-opaque back. An infrared-sensitive camera is positioned over the playing card back and receives infrared information passing through the playing card. A filter on the camera filters out at least some visible and some infrared radiation (infrared radiation is defined herein as radiation above 700nm wavelengths up to 2300 nm, preferably at least 750nm or at least 780 nm up to about 2300nm), allowing a defined range of infrared radiation into the camera. The camera captures radiation within the defined range of radiation and transmits (and/or
temporarily stores) signals based on the captured radiation. A processor receives the transmitted signals and executes code to define patterns in the captured radiation. The defined patterns include image content of suit and rank on the image face of the playing card.

The filter has defined cut-off range and a maximum transmission range. The maximum transmission range is within the near infrared range, such as between 700 or 780nm and 1100nm and even up to 2300 nm. It is also possible to use an Infrared Vidicon camera with IR sensitivity of up to 2200 nm. (Hamamatsu is the name of one camera manufacturer but there are others.) There are numerous specific methodologies within the generic scope of the present technology. One subgeneric method uses radiation passing through the playing card that is emitted below the image face of the playing card and transmitted through the playing card to the camera. Alternatively radiation may pass through the card from radiation emitted above the card, with a camera below the card.

A second subgeneric method uses infrared radiation passing through the playing card that is emitted above the image face of the playing card, passes through the playing card back a first time and is reflected, then transmitted through the playing card back a second time to the camera. In the second subgeneric method, light passing through the playing card back the first time is emitted by an infrared source above the back of the playing card. Low intensity lamps may be provided above the gaming table, in the ceiling, as wall lights or as a standing lamp. The back of the playing card may be in contact an inner surface (capable of transmitting infrared radiation, i.e., transmissive of infrared radiation) on a card delivery shoe or tray, and the emitted light passes through the inner surface a first time and the reflected infrared radiation then passes through the inner surface a second time and is captured by the infrared sensitive camera. It is to be understood that the use of an underlying card as an infrared radiation reflective surface while it must also be able to transmit radiation through a similar surface twice is not contradictory, but is a surprising aspect of the present invention. An analysis of the functional capabilities will support this aspect of the present technology.

Assume that a playing card absorbs and reflects a maximum total of X% of infrared radiation (of a defined wavelength range) passing through the card (including the back side of the playing card) and the top (back side) of the card reflects (does not include absorption) a minimum of Y% of infrared radiation of the same wavelength range. Therefore, reflected radiation passes through the card twice and must be reflected off an adjacent card once. In
approximating mathematic terms, with an initial intensity striking the back of the top playing card, the scenario would be expressed as follows:

With an incident IR radiation intensity (Ir) striking a top of two cards, the intensity Ir₁ passing through the first card would be (100-X)%/X times Ir. That is the intensity (Iri) that strikes the back of the underlying playing card. Of that incident radiation striking the underlying card, (Y)% is reflected. Therefore Y Iri is reflected off the back of the underlying card. Approximately (100-X)% of that Y Iri is transmitted through the playing card. It is understood that Y<X (as X includes reflection Y and absorption components).

Using prophetic but reasonable values for X and Y, the practical use of this reflective system can be appreciated. Assuming that X% is 80% and Y% (reflection) is 40%, with a normalized Ir of 100 light units, the intensity (Iri) that strikes the back of the underlying playing card is 20 light units. The amount reflected off the underlying card would therefore be 40% x 20 light units, or 8 light units. The amount transmitted through the top card (the second transmission through that card) would be (100-80)% x 8 light units, or a minimum of 1.6 light units. This is sufficient amount of infrared radiation to enable cameras to receive and interpret reflected image data. This has been proven by actual working models.

In addition to these conservative numbers, it must be appreciated that as cards are differentially absorbing the infrared radiation (with higher or lower infrared optical densities in the suit and rank images), with the 1.6 light units being the minimum transmitted through the card the second time, more is transmitted through lower optical density areas of the playing card. The contrast is created by the difference in absorption creates the image data. Where the transmission and reflection pathways are approximately perpendicular, the amount absorbed/reflected in low optical density image areas can be substantially less than in high optical density areas. The perpendicular path passes through the low optical density area twice and the high optical density area twice, increasing the contrast.

In the first subgeneric method, the infrared radiation passing through the playing card may be emitted from infrared emitters within a card handling device, such as a card handling device selected from the group consisting of a delivery shoe, shuffling apparatus or card randomizing apparatus.

In both methods, the playing card may be present within a playing card delivery shoe, and the image content comprises image content of a top playing card in the delivery shoe. At
least some reflected radiation is reflected from a back of an at least second playing card
within the delivery shoe adjacent the top playing card. The inner surface on the card
handling device (e.g., the panel over the cards in a delivery tray in a shuffler or delivery shoe)
may be translucent to a range of infrared radiation within the transmission range between
700nm, 750nm or at least 780nm up to 1100nm and even up to 2300nm. A system for
controlled provision of image content of faces of a playing card may have:

a) a support surface for playing cards;
b) a source of infrared radiation;
c) an infrared sensitive camera; and
d) a processor.

The infrared sensitive camera is positioned to capture infrared radiation transmitted through
the playing cards and transmit information based on the captured radiation to the processor;
and the processor is configured to provide suit and rank information of a playing card through
which the infrared radiation was transmitted.

As with the two subgeneric aspects of the present technology, the source of infrared
radiation is below the playing card through which the infrared radiation was transmitted and
the infrared camera is above the playing card through which the infrared radiation was
transmitted, or the source of infrared radiation is above the playing card through which the
infrared radiation was transmitted, so that the infrared radiation is transmitted through the
playing card after reflection and the infrared camera is above the playing card through which
the infrared radiation was transmitted. Alternatively the source of IR radiation may be above
the playing card and the camera is then below (as in an important application, a dealing,
delivery or shuffler output shoe with camera, prism-mirror under the first card and IR light
built above and into front cover of the shoe.

The source of infrared radiation may be located in a gaming table, in a device sitting on
top of the gaming table (box, tray, shoe, etc.) in a playing card delivery shoe or in a playing
card shuffling device. The support surface for playing cards may be a casino gaming table
top or be within a playing card delivery shoe or shuffler and a source of infrared radiation is
above and external to the playing card delivery shoe or shuffler. An upper surface above the
playing card support surface may transmit infrared radiation, preferably in a range between
780nm and 1100nm, although IR emissions up to 2300nm may be used. A video display
screen may be present, and the processor may be configured to transmit image data of the
playing card suit and rank to the video display screen and the video display screen is
configured to enable display of the transmitted image data.

In photography, a filter is a camera accessory consisting of an optical filter that can be
inserted in the optical path. The filter can be a square or oblong shape mounted in a holder
accessory, or, more commonly, a glass or plastic disk with a metal or plastic ring frame,
which can be screwed in front of or clipped onto the lens.

Filters modify the images recorded. Sometimes they are used to make only subtle changes to
images; other times the image would simply not be possible without them. In monochrome
photography, colored filters affect the relative brightness of different colours; red lipstick
may be rendered as anything from almost white to almost black with different filters. Others
change the color balance of images, so that photographs under incandescent lighting show
colours as they are perceived, rather than with a reddish tinge. There are filters that distort
the image in a desired way, diffusing an otherwise sharp image, adding a starry effect, etc.

Supplementary close-up lenses may be classified as filters. Linear and circular polarising
 filters reduce oblique reflections from non-metallic surfaces.

Many filters absorb part of the light available, necessitating longer exposure. As the filter is
in the optical path, any imperfections—non-flat or non-parallel surfaces, reflections
(minimised by optical coating), scratches, dirt—affect the image.

There is no universal standard naming system for filters. The Wratten numbers were adopted
in the early twentieth century and are used by several manufacturers. Color correction filters
are often identified by a code of the form CC50Y—CC for color correction, 50 for the
strength of the filter, Y for yellow.

Optical filters are used in various areas of science, including in particular astronomy; they are
especially the same as photographic filters, but in practice often need far more accurately-
controlled optical properties and precisely-defined transmission curves than filters
exclusively for photographic use. Photographic filters sell in larger quantities at
correspondingly lower prices than many laboratory filters.
A #87C filter will filter out all visible light, but since these filters gradually filter out more and more light as the wavelength increases, the #87C will also filter out a good amount of the infrared light. All though it filters out all visible light, it still lets in enough of the infrared spectrum for clear crisp images. The #25 filter lets in a significant amount of red light, and is often used in traditional photography because it allows image previewing through the viewfinder.

The following is a table of % light transmission at different wavelengths for a few of the filters specified above. One should be able to figure out the approximate behavior of the other filters by comparing them to this table.

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>% Transmission</th>
<th>#25</th>
<th>#89B</th>
<th>#87</th>
<th>#87C</th>
</tr>
</thead>
<tbody>
<tr>
<td>@ 550 nm</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>@ 600 nm</td>
<td>50.00</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>@ 650 nm</td>
<td>87.60</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>@ 700 nm</td>
<td>89.50</td>
<td>11.20</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>@ 750 nm</td>
<td>89.50</td>
<td>83.10</td>
<td>03.50</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>IR radiation</td>
<td>800 nm</td>
<td>89.50</td>
<td>88.10</td>
<td>56.90</td>
<td>3.00</td>
</tr>
<tr>
<td>IR radiation</td>
<td>850 nm</td>
<td>89.50</td>
<td>89.20</td>
<td>78.50</td>
<td>48.40</td>
</tr>
<tr>
<td>IR radiation</td>
<td>900 nm</td>
<td>89.50</td>
<td>89.90</td>
<td>81.90</td>
<td>80.60</td>
</tr>
<tr>
<td>IR radiation</td>
<td>950 nm</td>
<td>89.50</td>
<td>90.40</td>
<td>83.60</td>
<td>86.50</td>
</tr>
<tr>
<td>IR radiation</td>
<td>1000 nm</td>
<td>89.50</td>
<td>90.50</td>
<td>85.30</td>
<td>89.20</td>
</tr>
</tbody>
</table>

A consideration of the Figures will assist in a further appreciation of the scope and content of the present invention.

Fig. 1 shows a perspective view of a playing card delivery shoe 300 useful within the scope of the present technology in combination with an overhead camera system 330. The deliver shoe 300 is shown with its front delivery portion 302, a finger slot 304 for removal of playing cards (not shown), its back 301, side 306 and top panels 316 of the delivery shoe 300. A more modern mechanized shoe 300 is shown with card entry panel cover 314, side information and activation controls 308, with dealer information display 312 and activation button 310. To assist in enablement of one aspect of the present invention, the infrared penetrable front panel 320 and the internal infrared emission system 322 is shown. The emission system 322 may be any technologically available source of IR, especially IR within the range of 780-1200nm, and more preferably within the range of 780 to 1100nm. The
emission system 322 should provide enough fluence of IR radiation that the IR radiation will penetrate the playing cards (not shown) behind the front panel 320 and above the mission source 322 and then be received by the camera system 330 which is often present on the ceiling in a gaming environment. These camera systems 330 are part of what is referred to as the "eye-in-the-sky" viewing systems within casinos. The infrared radiation emitted from the system 320 penetrates at least one playing card that has been advanced into the front end 302 of the delivery shoe 300, and may include two or more (up to a reasonable limit to minimize IR emission requirements) playing cards. It is also an enabled embodiment of the present technology to use ambient or enhanced IR emissions in the casino environment to penetrate the IR transmissive cover 320, penetrate a top card (the first card immediately under the plate 320), be reflected (in-part) by the top-side of the second playing card within the front end 302 of the delivery shoe 300 and then repenetrating IR transmissive cover 320 and then be transmitted to and captured by the camera system 330. It is surprising that, especially with a cut-off filter 334 within the cover 332 or as the cover 332, modest amounts of ambient IR radiation can function accurately in this type of system. Filtered radiation (having passed through cover 332 and cutoff filter 334) is then captured by the camera element 336 and the data from the captured signal (processed or not by a processor within the camera element 336 is the transmitted through an output port (wired or wireless) 338 to a system that can electronically read and/or display the captured IR image data of the playing card information.

The cutoff filters are selected upon design parameters that are still novel and non-obvious within the context of the present technology, even though cutoff filters may be themselves commercially available with the properties that might be needed. The cutoff filters effectively limit the radiation to which the cameras are sensitive to the range of radiation passing through the playing cards. For example, if the emission system or ambient IR penetrating playing cards has its maximum IR range within 800-1000nm, the use of a cutoff filter allowing most of all radiation between 800-1000nm to penetrate the filter, while absorbing or blocking most radiation below 790nm and above 1010nm is effective is provide a sharper image, with higher contrast, of the playing card(s) by removing background, or extraneous radiation wavelengths from the camera system. As visible light is likely to be more intense than the IR radiation passing through the cards, it would be more difficult for a system to try to discern what portions of the image data were useful in reading card information when the vast amount of energy entering the camera (if unfiltered) would likely
be visible and/or ultraviolet radiation. The cutoff filter increases the likelihood that most radiation received by the camera is useful card image information.

The cutoff filters would similarly work within the camera information receiving capability on a tabletop viewing system, such as that shown in Fig. 2. Fig. 2 shows a gaming table layout with through-card reading capability on the table top itself 200 in combination with an overhead camera 330. All numbering that is identical with that from Figure 1 represents an identical component. The tabletop 200 is shown with a base layer 202, a surface layer 206 (which, by way of non-limiting examples, may be felt or a felt laminate), and interface or reflective and/or transmissive layer 207, and a playing card 210 on the surface 208 of surface layer 206. An optional (but preferred) system of IR emitters 204 embedded in the base layer 202 of the tabletop 200 is shown. Where the IR emitters 204 are present in a system, emitted IR radiation passes out of the base layer 202 and through the interface or transmissive layer 207, through the surface layer 206, through the playing card 210 (creating differential contrast images of playing card faces or values (not shown) and is captured by one or more camera systems 330. The captured contrast images are then processed as described in the operation of data capture and image formation in Figure 1. An ambient source of IR radiation 220 which could be on walls or the ceiling, emitting effective but harmless-to-human levels of background IR radiation is also shown. These sources of IR radiation would emit IR radiation at wavelengths designed to benefit or optimize the performance of reflection off the surface 208 of the tabletop 200 or reflect off interface or layer 207 (where that layer or interface is constructed of IR reflective material). For example, if the cutoff filter layer 334 in the camera system 330 and the camera 336 were designed to have maximum imaging capability between 800nm and 850nm, the IR source 220 would emit at maximum intensity between 800 and 850nm, and the surface 208 and/or the surface layer 206 would be designed to efficiently reflect IR radiation between wavelengths of 800nm and 850nm.

Fig. 3 shows a perspective view of a delivery shoe 400 with novel card reading capability using through-the-card imaging and refraction/reflection technology. The delivery show 400 (which may alternatively be the front delivery end of a shuffling or randomizing apparatus) has a housing 402, having a top 406, sides 408, first floor 410, back 412 and a second floor 418. A sliding pressure block 420 is shown pressing against a set of playing cards 422 in the delivery shoe 400. A roller 436 is shown on the bottom of the sliding
pressure block 420 to assist its movement along the second floor 418 to provide pressure against the playing cards 422 to assure they are pressed against front slope 414 and available for removal through opening 432. The first floor 410 and the second floor 418 form a space (volume) therebetween to allow components of the system to be positioned. A prism or mirror 404 is positioned beneath the front plate 414 within the space between the first floor 410 and second floor 418. The prism or mirror 404 (hereinafter referred to only as the prism) is in radiation receiving alignment with at least one electromagnetic radiation emitter, especially an infrared radiation emitter 430 (shown as three IR-emitting LEDs, which may be in the horizontal alignment shown, vertical alignment, diagonal alignment or organized arrangement). The infrared radiation emitted from the emitters 430 are redirected (refraction and or reflection) after passing through at least one playing card within the set of playing cards 422, the technology having been proven with transmission through at least two or at least three cards clearly, and capability expected through more cards, such as up to ten cards). (IR may be transmitted through 2 or 3 cards easily, but more would require either more radiation or extended positioning of playing cards, because their indexes would overlap. As many as about ten cards spread with their indexes open- this would take space of about 2.5 inches, which can be done, but which is generally too much to capture with camera lens because indexes would be to small; also, slide which holds cards and roller would have to be almost horizontal). With dense paper cards, it is likely that only one card may be transmitted with IR through the card. The redirected from the prism 404 to a camera system 438 having a receiving element or lens or focusing element 404 and a output line 444 passing through an I/O port 442 or the like. It is important to note that essentially all standard playing cards may be used in this system, at least with single card see-through reading. Unlike some other systems where special cards must be marked or used, the present technology on see-through cards is useful with commercially available standard playing card decks.

The light (electromagnetic radiation) passing through the cards 422 is redirected towards the camera system 438. The redirection may be by prism or mirror as previously stated, but a panel of optical fibers (not shown) or even a semiconductor area detector with leads through the I/O port 442 (not shown), or any other radiation capture device that can provide signals of the radiation image received.

A top card symbol of the Three of Hearts 434 is shown beneath the front plate 414. The card is shown in right-read orientation, while in actual use, a mirror image will be
viewed, if camera is positioned above the card and right-read orientation will be viewed if the camera is positioned below the card. Because of the position of the radiation emitters 430, radiation is transmitted through the playing cards 422 at a position at a card corner where symbols are present. The image signals received and transmitted through the I/O port 442 or along the output line 444 are sent to a processor (not shown) that executes code (e.g., including card recognition software) to convert the captured signals into information identifying the card(s) through which the radiation has passed. As radiation is attenuated passing through each playing card, and as each card is slightly angled so that overlying symbols are not in perfect registration, software can recognize and differentiate among multiple images from the radiation penetrating through multiple cards. This can be expedited for viewing the card index by slightly pulling ahead the first card, as by 1/3 the length or width of the cards, as when the dealer starts dealing. By recognizing a forward-most (relative to the front plate 414) image of symbols captured, and then further differentiating among the other sequential sequences of images captured (assisted by the spacing provided by angling and thickness of playing cards), suits and/or rank of multiple cards can be determined from the radiation of the emitters 430 passing through the playing cards 422. In this manner, multiple playing cards at the ends of the delivery shoe tray (or shuffler delivery tray) may be read. If the delivery tray holds cards in a more horizontal position (as may be the case where multiple cards that form a single hand to be delivered by a dealer to player positions), the emitters may be more vertically oriented and the camera may be conveniently located closer to the faces of the playing cards. Cards may be expelled into the delivery tray one at a time (for ease of reading and as enabled by some existing shufflers) or in sets of, for example, 1-7 playing cards which may be read in sets.

Fig. 4 shows a side view of a gaming table system 500, alternative undertable lighting systems 512 and 516 and camera system 514 enabling practice of one aspect of the present technology. This gaming system 500 is provided with a radiation transparent or translucent structural support 504 having a radiation penetrable game marking top 506 (such as a felt top) with at least markings 510 thereon to identify placement areas for cards and placement areas for wagers. Variable independent or overlapping structures are shown in Figure 4 to conserve space. One independent system has an diffuse radiation-emitter 516 below the surface of the structural support 504 so that emitted radiation passes through the game marking top 506 and creates differential optical densities as the radiation passes through the markings 510 and around (if opaque) and through (if transparent or translucent) an object
(chip, playing card, identification tag, marker, currency) placed on the game marking top 506. After the radiation from emitters 516 passes through or around the object (not shown) especially over the markings 510, it travels as radiation to at least one overhead camera (e.g., 516b an overhead system on the ceiling or supported over the system) where received image data is processed by a computer to identify image content, including playing card rank, suit and content and use that information for display or hand reading, or strategy analysis and/or player comping.

An alternative structure can use a bank or independent numbers of radiation emitters 513 below a radiation transparent support 504, with the orientation and alignment of the emitters 512 and either a single overhead camera 514b or a bank of overhead cameras 514a 514b 514c that receive the emitted radiation. For example, emitter 512b creates a linear radiation path 518b that passes through the transparent/translucent support base 504, the marking 510b on the table system 500 to the aligned overhead camera 514b. Similarly, using a single overhead camera 514b, emitter 512a emits the preferred wavelength of radiation through the transparent/translucent support base 504, the marking 510a on the table system 500 to the aligned overhead camera 514b.

The table system has legs 502 that support the radiation transparent support 504 and the covering 508. The cameras 514a-c receive image-content information that passes through objects (e.g., infrared radiation passing through playing cards, cellulosic materials, paper currency, player cards, bar-code tickets, thin transparent polymeric materials, etc.) to provide substantive image content of the object or when passing around the object (e.g., an opaque chip, medallion, coinage etc.) provides object presence information (e.g., at least one chip has been placed at a wagering position).

A system within the scope of this technology may include a table gaming system wherein the source of infrared emitters emits wavelengths within the wavelength range of 800 - 1200 nanometers is the support surface is transparent to at least infrared radiation between wavelengths of 800 to 1200 nanometers, and the infrared sensitive camera is sensitive to at least some wavelengths between 800 and 1200 nanometers (even to 2300nm), and wherein the emitters and cameras are aligned so that emitted radiation passes through the support surface and through or around at least one object on the support surface towards the infrared camera in sufficient intensity as to allow for object recognition or see-through reading of the object. The system may include the at least one object as a playing card and at least 5% of
incident emitted infrared radiation hitting a surface of the playing card passes through the playing card to the infrared camera. The system may include the at least one object as a wagering token or chip and less than 5% of incident emitted infrared radiation hitting a surface of the playing card does not pass through the object to the infrared camera.

The lighting systems 512 can also be canisters that are replaceable within the table top system (e.g., through holes in the radiation penetrable game marking top 506). In this case, if all illumination is through canisters and their lenses or covers (and does not have to be done through a radiation penetrable game marking top 506 or even through a radiation transparent support 504, neither the game marking top or the support have to be transparent. To see the types of structures similar to those that may be provided as a canister, refer to U.S. Patent Nos. 6,299,534 and 7,367,884 (Breeding patents) which show optical-electrical devices that have transducers that emit and receive reflected radiation. These types of devices can be used as emitters and the reflected radiation receiving capability can (and should) be eliminated. In this way, the canisters operate as sources of emitted radiation according to the practice of the present technology by providing the IR radiation source (e.g., 700 to 2300nm) as IR emitters, such as IR LEDs. Canisters similar to those of Figures 7, 8, 9 and 10 of US 7,367,884 (with or without the necessity of a requirements of sensing capability in the canister) can be used in the practice of the present invention.

Additionally, canisters may be provided with weight sensing capability to assist in determining the presence of heavier objects, such as chips or tokens provided on the surface of the emitters. This is useful where the emitters are used in locations where wagers must be positioned. Weight sensing elements such as scales, springs, flexing sensors, pressure sensors, force sensors, and the like may be incorporated easily in the canisters, especially along or under the housing 136 or cover plate or token supporter 138 shown in Figures 7 and 8 of US 7,367,884. The weight sensing device would be in electrical or wireless communication with a processor to receive information. As chips at a specific location tend to be a uniform weight, the steady weight registered at a specific wagering position can be quantified into a specific number of chips. This is especially useful in roulette, where all tokens for a player usually have the same nominal value, so that identifying a specific number of chips also identifies a specific value for each wager.
The weight sensors may, for example, include nut are not limited to analog weight sensors, precision balance scale and mechanical balance scales, strain gauge sensors connected to Wheatstone bridge circuits and piezoelectric weight sensors.

Property variations between strain gauge sensors and strain gauge sensors can be summarized as follows. Low Impedance Voltage Mode (LIVM) technology in the piezoelectric force sensor controls press fit modules until 444 kN. LIVM technology may consist in a miniature IC metal oxide silicon field effect transistor (MOSFET) amplifier built into the housing of the sensor. The amplifier converts the high impedance voltage signal from the quartz element to a much lower output impedance level, so the readout instrument and long cable have a neglect effect on the signal quality. Because the high impedance input to the IC amplifier is totally enclosed and thus shielded by the metal housing. The LIVM sensor is relatively impervious to external electrostatic interference and other disturbances. The sensor amplifier is a common drain, unity gain "source follower" circuit with the source terminal brought out through a coaxial connector on the sensor body Low output impedance (less than 100 ohms) makes the sensitivity of the LIVM sensor independent of cable length within the frequency response limits outlined in the chart. Basic system sensitivity does not change when cables are replaced or changed. The sensitivity of the LIVM sensor is fixed at time of manufacture by varying the total capacitance across the quartz crystal element. The highest possible voltage sensitivity is obtained with no added capacitance across the element. The discharge time constant (TC) of the low Impedance Voltage Mode (LIVM) is a very important factor when considering the low frequency and the quasistatic response capabilities of an LIVM system. The TC value related on the data sheet means the time (in seconds) required for a sensor output voltage signal to discharge 63% of its initial value immediately following the application of a long term, steady state input change, this effect provide on quasi-static behavior of the force sensor. In all applications, where is necessary monitoring processes with a constant value of reaction force, a quasi-static behavior is fundamental to have a control, although if the piezoelectric sensor don't own a quasi-static behavior, in all situation where the force continue in constant value, the value of force goes immediately to zero value.

When using strain gauges any elastic deformation of the measuring body is first converted to a change in strain gauge resistance, so that a Wheatstone bridge circuit electrical output signal can then be generated.
By contrast the basis of the piezoelectric effect is that crystals under compressive loading generate an electric charge that is directly proportional to the force applied.

The weight sensing component may also be a flexible piezoelectric resistor having at least two cathodes thereon. When current passes through the piezoelectric resistor and pressure (e.g., weight) causes changes on the resistor, the current changes. This type of weight/pressure indicating and measuring technology is shown in U.S. Patent No. 8,132,468 (Radivojevic). These piezoelectric sensors comprise nanotubes or nanofilaments in an elastic carrier layer. Another aspect of this weight measuring technology is the used of chips of different values with individual different weights.

It is also possible within the scope of the present technology to use chips that are translucent to infrared radiation, such that multiple chips may be identified and counted using this system. By using chips, tokens or markers that are transparent or preferably only translucent to infrared radiation (or even visible radiation and UV radiation), the camera system (overhead or even reflective) may be used to read numbers of chips and even amounts of value in chips. As the translucent chips can be provided with radiation attenuating fiducials, markings, identification marks, pattern or symbols, differing optical densities to the emitted radiation, and the like which can identify the value of chips, the radiation transmitted through the chips can be used to count chips and total values of chips being wagered at a specific position. This is shown in Figure 5, which shows the following patterns and markings identifying numbers and values of chips in single images, even through multiple chips. The features of the chips are shown without separately distinguishing the chips as overlying or underlying, as the actual images created by the penetrating radiation show all edge features and markings, as would an X-ray, so that the Figure 5 images (5A, 5B, 5C, 5D, 5E, 5F, 5G and 5H) show realistic rendition showing all features of all chips. It is to be noted that the valuing of chips by these methodologies can be used not only for wagers, but also for payouts by the casino and for cashing in chips. The chip valuation can also be manually verified, but the electronic verification (with or without verification) can be used in accounting functions for individual players and for the total number of players at the table. There may be multiple weighing positions at each player position, as different games may have different numbers of distinct wagers, as in Three-Card Poker™ games, Four-Card Poker™ games, Ultimate Texas Hold’Em™ poker games, Pai Gow Bonus™ poker games and the like. By using these accurate wager, payout and cash-out (cashed-in) value
determinations and the use of card-reading and hand reading, and hand evaluation systems, a complete record of a game played can be recorded, verified and controlled to prevent fraud and error.

Figure 5A shows a single chip 550 with a nominal value of 1 unit having unique radiation attenuating marking 550a identifying the chip as a 1 unit chip.

Figure 5B shows a single chip 552 with a nominal value of 5 units having unique radiation attenuating marking 552a identifying the chip as a 5 unit chip.

Figure 5C shows a single chip 554 with a nominal value of 25 units having unique radiation attenuating marking 554a identifying the chip as a 25 unit chip.

Figure 5D shows a single chip 556 with a nominal value of 100 units having unique radiation attenuating marking 556a identifying the chip as a 100 unit chip.

Figure 5E shows two chips 550, 554 overlying each other. The two distinct markings 550a, 554a attenuating emitted radiation are shown as distinct elements of the image that can be optically read by a distal viewer having the infrared image converted to a visible display, or by purely mechanical means, with an image reader interpreting the distinct markings.

Figure 5F shows three chips 550, 554, 556 overlying each other. The three distinct markings 550a, 554a, 556a attenuating emitted radiation are shown as distinct elements of the image that can be optically read by a distal viewer having the infrared image converted to a visible display, or by purely mechanical means, with an image reader interpreting the distinct markings. The automatic reading function would identify one chip each of 1 unit value, 25 unit value and 100 unit value and total that as 126 units wagered at that position.

Figure 5G shows four chips 550, 552, 554, 556 overlying each other. The four distinct markings 550a, 552a, 554a, 556a attenuating emitted radiation are shown as distinct elements of the image that can be optically read by a distal viewer having the infrared image converted to a visible display, or by purely mechanical means, with an image reader interpreting the distinct markings. The automatic reading function would identify one chip each of 1 unit value, 5 unit value, 25 unit value and 100 unit value and total that as 131 units wagered at that position.
Note that the image in FIG. 5G is of four perfectly overlain and aligned chips of different values, and that each chip marking is distinctly viewable because the markings are impossible to be positioned where one marking completely blocks reading of a different marking because of positioning and size, and location of markings. Even the similar markings of FIG. 5E can never be confused. Modern chips tend to vary in weight among different casinos in the U.S., with disclosed weights between about 8 and 14 grams/chip, typically between 8.3g and 12.5g per chip. In the practice of the present technology, greater standardization may be provided or each casino can use its own unique weight of chips. A single system may be self-educating and can be customized and self-adjusting for weights of chips. For example, at the beginning of each day or shift change, one single chip (at a time) and then collectively one of each chip at the same time. The system will self-adjust and self-calibrate for the chips of the actual weight (whether unique or not) used at that facility. This self-calibration will assure that the weight-sensing system if functional and accurate each day and even for each session (which may be 2, 4, 6, or 8 hours).

It is possible that chips of similar value can be precisely positioned such that identical markings may be perfectly aligned in a perfectly vertical emission, penetration and receiving of the emitted radiation image. Even with a small probability of this occurring, the use of an accompanying weighing function (as described above) in combination with the value reading would indicate to the server or observer that there is a deficiency in the reading at a particular position. However, having the radiation emission, the direction (angle) in which radiation passes through the stack of chips, and the angle at which a camera receives the transmitted radiation image will alleviate this issue. As shown in FIG. 5H, with this angularity of transmission of the radiation, a perfect stack would have the appearance of being off-set. This would prevent readings that would completely obscure underlying values, even if aligned along a vertical perspective. As shown in FIG. 5H, two one unit chips 550 are in a stack, one on the top of the stack and one on the bottom of the stack. The stack is in perfect vertical alignment, with all chips concentric. However, because of the angularity of the radiation creating the image, the two 1 unit markings 550a are clearly and separately visible.

Therefore, another distinct aspect of the see-through technology described herein includes the use of see-through (radiation transmitting or translucent) chips having markings thereon that can distinguish there value based on different imagery produced by different optical and opaque and attenuating image density within the chips.
Fig. 6 shows a side cutaway view of a gaming table 600, under-table lighting system 610 and camera system 612, and weighing system 614 for chips enabling practice of one aspect of the present technology. The table 600 has a top infrared translucent/transparent support surface 604 supporting a top layer 602 which may be traditional felt or special IR transparent covering. Individual wagering areas 614 have at least a portion of a weighing system associated therewith, as the weight sensors 618 and their communication link 616 to the weighing areas. Non-wired (e.g., RF) communication links may also be used. At the bottom of the table 600 may be a base support layer 608, supporting a layer 606 having IR light(s) 610 that emit upwardly through layers 604 and 602 to the camera 612.

The present technology therefore also includes a system for controlled provision of image content of wagering chips at a wagering position on a gaming table including:

a) a support surface on the gaming table for the wagering chips;
b) a source of infrared radiation;
c) an infrared sensitive camera; and
d) a processor;

the infrared sensitive camera positioned to capture infrared radiation transmitted through the wagering chips at the wagering position and transmit information based on the captured radiation to the processor; and

the processor configured to provide at least numbers of chips at the wagering position.

The wagering chips of different value in a single stack of chip may have different infrared viewable indicia thereon and the infrared sensitive camera captures infrared radiation transmitted through the wagering chips at the wagering position and transmit information based on the captured radiation to the processor which images more than one different viewable indicia and the processor executes code to identify different value among chips in the stack of chips.

Therefore a method within the present technology may be used including a method for reading information from a chip or marker while one or more chips are stacked on a gaming surface (e.g., table). The chips are at least translucent to specific wavelengths of radiation, such as the IR portion of the spectrum. An infrared-sensitive camera (which may be the same camera used to identify individual playing cards) may be used over the chips to
identify individual chips and collections of chips by number of chips and value of chips. The term over means on an opposite side of the chip from the source of radiation that penetrates the translucent chip. The camera receives infrared information passing through the chip. A filter on the camera filters out at least some visible and some infrared radiation (infrared radiation is defined herein as radiation above 700nm wavelengths up to 2300 nm, preferably at least 750nm or at least 780 nm up to about 2300nm), allowing a defined range of infrared radiation into the camera. The camera captures radiation within the defined range of radiation and transmits (and/or temporarily stores) signals based on the captured radiation. A processor receives the transmitted signals and executes code to define patterns in the captured radiation. The defined patterns include image content of numbers of chips and values of chips as indicated above. With chip reading, chips transparent to visible radiation and visible light sensitive cameras may be used, but that light might be more annoying to players.

The see-through technology need not be used at the extreme ends of the delivery shoe or on the shuffler. Numerous designs exist for intermediate reading of playing cards, and so the present card-imaging technology may be used in known shuffler and mechanical card delivery trays (where cards are moved by electromagnetically operated components) in intermediate positions, as between card input areas and the card delivery areas. The cards may be read while moving, or may be stopped as individual cards or in sets of cards, or in individual hands, as desired.

This method may use physical playing cards wherein the randomization is effected by shuffling of the physical playing cards, as by manual shuffling or an electromechanical shuffler. The physical playing cards are preferably a single deck of physical playing cards and randomization is effected by automated electromechanical shuffling of the physical playing cards. The playing cards may be virtual playing cards and the method is performed on a system comprising a processor, a video display screen and player input controls and the processor displays hands at a virtual player position and a virtual dealer position and a random number generator provides random individual cards for the first subset of playing cards and the second subset of playing cards. The set of playing cards should comprise at least a standard deck of playing cards, fifty-two cards having four suits (spades, hearts, diamonds and clubs) having ranks from 2 to Ace. Multiple decks and/or specialty cards may also be included with the deck. The deck(s) must be randomized by shuffling to provide cards in a random order. The transformation of cards into a random order must be done before the
play of each round of the game so that the cards provided cannot be predicted with any significant degree of certainty. The dealer controls the play of the game and dictates the rules of play of the game. The dealer will not allow cards to be dealt to player positions unless the appropriate wager is verified by the dealer. The dealer segments the shuffled set of playing cards into random content subsets of exactly the number of cards that the dealer must provide in each step of the method. The cards may be manually dealt or automatically dealt by a shuffling apparatus. The shuffling apparatus may be a batch shuffler or a continuous shuffler. Cards may be provided one at a time from a delivery position in the shuffler, entire randomized deck(s) may be provided from the shufflers, or individual hands of exactly three cards for delivery to individual player positions and the dealer position. There are a number of variations in the play of the game that may be used.

The shuffling may be performed by a number of various methods, including manual shuffling to produce a randomized set of playing cards. The automatic shufflers may operate by either actually shuffling a portion of or entire set of playing cards (e.g., one or more decks of playing cards), or by providing hands or subsets of playing cards randomly out of the original complete set of playing cards. The cards may be batch shuffled or continuously shuffled (returned, spent cards from previous hands are returned to the machine and randomly distributed among cards already in the machine). The shuffling mechanism may be accomplished by use of carousels (or linear moving stacked arrays) of multiple compartments into which cards are inserted (randomly or in predetermined locations among the compartments) and then unloaded from the compartments (randomly or in predetermined order of compartments) so that random hands or subsets of playing cards are distributed to a delivery area for distribution by the dealer. The cards may also be delivered to a delivery tray by random removal (e.g., random ejection as understood in the art, or random removal by any other technology) from the original set and delivery of the randomly withdrawn/removed cards to the delivery tray to form random hands or random subsets in the delivery tray.

Among the various types of shufflers available commercially into which this technology may be incorporated include, but are not limited to: U.S. Patent Nos. 8,544,848; 8,480,088; 8,267,404; 8,150,157; 8,025,294; 8,011,611; 7,988,152; 7,976,023; 7,967,294; 7,764,836; 7,753,373; 7,677,566; 7,677,565; 7,669,852; 7,661,676; and 7,073,791.

The see-through card imaging technology described herein can be integrated into these and other shufflers at strategic points in card movement or card stoppage using the
skills of the ordinary artisan. The method may have radiation passing through the playing card is emitted above the image face of the playing card and transmitted through the playing card to the camera.

The infrared radiation passing through the playing card may be emitted above the image face of the playing card, passes through the playing card back a first time and is reflected (e.g., by a mirror), refracted (e.g., by a prism) or collected then transmitted (e.g., by fiber optics) to the camera. The method may be practiced wherein the back of the playing card is in contact an inner surface on a card delivery shoe or tray, and the emitted light passes from or through the inner surface a first time and is captured by the camera. The infrared radiation passing through the playing card may be emitted from infrared emitters within an electromechanical card handling device.

It is possible, with a novel arrangement of elements can provide image recognition functionality with same-side, partial through the card imaging by reflection. For example, the radiation emitter may be relatively below the cards, mitted light/radiation reflected off the faces of cards, then transmitted through the cards to the camera. A prism, fiber optics or reflective surface (other than the cards) can assist in redirecting the reflected and through the card transmitted radiation to the camera. This is accomplished by simply putting the infrared radiation emitter(s) below the face of the cards in Figure 3.

As shown in reference materials cited herein, there are numerous imaging technologies that can be used with the captured image data to assist in determining playing card information (e.g., suit, rank, authenticity, verification of composite hands, etc.). Any of these software or computational or imaging technologies can be used in the practice of the present technology.

All publications referenced herein are incorporated in their entirety by reference.
WHAT IS CLAIMED:

1. A method of reading information from a playing card while an image face of the playing card is hidden by a visible-light-opaque back comprising:
   - an infrared-sensitive camera positioned over the playing card back receives infrared information passing through the playing card;
   - a filter on the camera filtering out at least some visible and some infrared radiation, allowing a defined range or wavelength of infrared radiation into the camera;
   - the camera capturing radiation within the defined range of radiation and transmitting signals based on the captured radiation;
   - a processor receiving the transmitted signals and executing code to define patterns in the captured radiation; and
   - the defined patterns including image content of suit and/or rank on the image face of the playing card.

2. The method of claim 1 wherein the filter has a maximum transmission range between 700nm and 2300nm.

3. The method of claim 2 wherein radiation passing through the playing card is emitted above the image face of the playing card and transmitted through the playing card to the camera.

4. The method of claim 2 wherein infrared radiation passing through the playing card is emitted above the image face of the playing card, passes through the playing card back a first time and is reflected, then transmitted to the camera.

5. The method of claim 1 wherein light passing through the playing card back the first time is emitted by infrared sources above the back of the playing card and refracted by a prism to the camera.

6. The method of claim 1 wherein light passing through the playing card back the first time is emitted by infrared sources above the back of the playing card and reflected by a mirror to the camera.
7. The method of claim 1 wherein light passing through the playing card back the first time is emitted by infrared sources above the back of the playing card and captured and transmitted by optical fibers to the camera.

8. The method of claim 5 wherein the back of the playing card is in contact an inner surface on a card delivery shoe or tray, and the emitted light passes from or through the inner surface a first time and is captured by the camera.

9. The method of claim 3 wherein the infrared radiation passing through the playing card is emitted from infrared emitters within an electromechanical card handling device.

10. The method of claim 3 wherein the card handling device is selected from the group consisting of a delivery shoe, shuffling apparatus or card randomizing apparatus.

11. The method of claim 3 wherein the playing card is present within a playing card delivery shoe, and the image content comprises image content of a top playing card in the delivery shoe.

12. The method of claim 9 wherein at least some transmitted radiation is reflected or refracted to the camera after transmission through a playing card.

13. A system for controlled provision of image content of faces of a playing card comprising:

   a) a support surface for playing cards;
   b) a source of infrared radiation;
   c) an infrared sensitive camera; and
   d) a processor;

   the infrared sensitive camera positioned to capture infrared radiation transmitted through the playing cards and transmit information based on the captured radiation to the processor; and

   the processor configured to provide suit and/or rank information of a playing card through which the infrared radiation was transmitted.

14. The system of claim 13 wherein the source of infrared radiation is above a back of the playing card through which the infrared radiation was transmitted and the infrared camera is below a face of the playing card through which the infrared radiation was transmitted.
15. The system of claim 12 wherein the source of infrared radiation is above the opaque back of the playing card through which the infrared radiation was transmitted, so that the infrared radiation is transmitted through and is reflected, refracted or captured and transmitted to a camera.

16. The system of claim 13 wherein a source of infrared radiation is located in a playing card delivery shoe or in a playing card shuffling device.

17. The system of claim 13 wherein the support surface for playing cards is a gaming table and a source of infrared radiation is above and external to the gaming table and the camera is below the surface of the gaming table.

18. The system of claim 14 wherein an upper surface above the playing card support surface transmits infrared radiation in a range between 700nm and 1100nm.

19. The system of claim 13 wherein a radiation cutoff filter is positioned between the playing cards and the infrared sensitive camera, the cutoff filter reducing amounts of visible radiation passing through the filter at a rate greater that the rate of reduction of IR radiation to which the infrared sensitive camera is sensitive.

20. The system of claim 13 wherein the source of infrared emitters emits wavelengths within the wavelength range of 700 - 1200 nanometers is the support surface is transparent to at least infrared radiation between wavelengths of 700 to 1200 nanometers, and the infrared sensitive camera is sensitive to at least some wavelengths between 700 and 1200 nanometers, and wherein the emitters and cameras are aligned so that emitted radiation passes through the support surface and through or around at least one object on the support surface towards the infrared camera in sufficient intensity as to allow for object recognition or see-through reading of the object.

21. The system of claim 20 wherein the at least one object is a playing card and at least 5% of incident emitted infrared radiation hitting a surface of the playing card passes through the playing card to the infrared camera.
22. The system of claim 20 wherein the at least one object is a wagering token or chip and less than 5% of incident emitted infrared radiation hitting a surface of the playing card does not pass through the object to the infrared camera.

23. The method of claim 1 wherein an infrared emitter provides infrared radiation from emitters positioned below an infrared transparent or infrared translucent support surface, a direction of emission includes paths that pass through the support surface to the camera which is positioned above the support surface a playing card on the support surface.

24. The method of claim 23 wherein the emitter comprises multiple infrared emitters attached to a bottom of the support surface.

25. The method of claim 23 wherein the emitter comprises an infrared emitters positioned below a bottom of the support surface.

26. The method of claim 2 wherein radiation passing through the playing card is emitted below the image face of the playing card and transmitted through the playing card to the camera.

27. A method of reading information from gaming elements on a gaming table comprising:
   an infrared-sensitive camera positioned over the gaming element receives infrared information passing through the gaming element;
   a filter on the camera filtering out at least some visible and some infrared radiation, allowing a defined range or wavelength of infrared radiation into the camera;
   the camera capturing radiation within the defined range of radiation and transmitting signals based on the captured radiation;
   a processor receiving the transmitted signals and executing code to define patterns in the captured radiation; and
   the defined patterns including image content of numbers of gaming elements and value of gaming elements.

28. The method of claim 27 wherein the gaming element comprises one or more chips having a wagering value identified in defined radiation attenuating markings on the chip.
29. The method of claim 27 wherein the gaming element comprises multiple chips, at least two chips having different wagering values, and wagering values of each chip is identified in defined radiation attenuating markings on individual chips.

30. A system for controlled provision of image content of wagering chips at a wagering position on a gaming table comprising:

   e) a support surface on the gaming table for the wagering chips;
   f) a source of infrared radiation;
   g) an infrared sensitive camera; and
   h) a processor;

   the infrared sensitive camera positioned to capture infrared radiation transmitted through the wagering chips at the wagering position and transmit information based on the captured radiation to the processor; and

   the processor configured to provide at least numbers of chips at the wagering position.

31. The system of claim 30 wherein wagering chips of different value in single stack of chip have different infrared viewable indicia thereon and the infrared sensitive camera captures infrared radiation transmitted through the wagering chips at the wagering position and transmit information based on the captured radiation to the processor which images more than one different viewable indicia and the processor executes code to identify different value among chips in the stack of chips.
INTERNATIONAL SEARCH REPORT

International application No.
PCT/US14/52566

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) A63F 1/02, 1/06, 1/18 (2014.01)
CPC A63F 1/06, 1/18, 2001/0491

According to International Patent Classification (IPC) or to both national classification and IPC.

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) Classification(s): A63F 1/02, 1/06, 1/18, G06K 9/00 (2014.01)
CPC Classification(s): A63F 1/06, 1/18, 2001/0491; USPC classifications: 463/31, 30; 382/181; 273/149R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched.

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)


Search terms used: near infrared playing card shoe prism mirror fiber, wagering chip, wheelchecks, plaques, jeton

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5-10, 12, 15-16, 20-26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20-26</td>
</tr>
<tr>
<td></td>
<td>US 5,941,769 A (ORDER, M.) August 24, 1999; figure 1; column 6, lines 7-24 and 57-64; column 7; lines 14-24.</td>
<td>5-6, 8</td>
</tr>
<tr>
<td></td>
<td>US 7,769,232 B2 (DOWNS, J. III) August 03, 2010; column 22, lines 35-54.</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>US 2005/0051965 A1 (GURURAJAN, P.) March 10, 2005; figure 3; paragraphs [0094-0095].</td>
<td>9-10, 12, 15, 16</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C.

* Special categories of cited documents:
  "A" document defining the general state of the art which is not considered to be of particular relevance
  "E" earlier application or patent but published on or after the international filing date
  "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  "O" document referring to an oral disclosure, use, exhibition or other means
  "P" document published prior to the international filing date but later than the priority date claimed

Date of the actual completion of the international search
29 October 2014 (29.10.2014)

Date of mailing of the international search report
05 DEC 2014

Name and mailing address of the ISA/US
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450
Facsimile No. 571-273-3201

Authorized officer:
Shane Thomas
PCT Helpdesk: 571-272-4388
PCT OSP: 571-272-7774
Form PCT/ISA/210 (second sheet) (July 2009)