Quantifying Total Operational Cost of Image Review Systems and the Cost Impact of Image Quality

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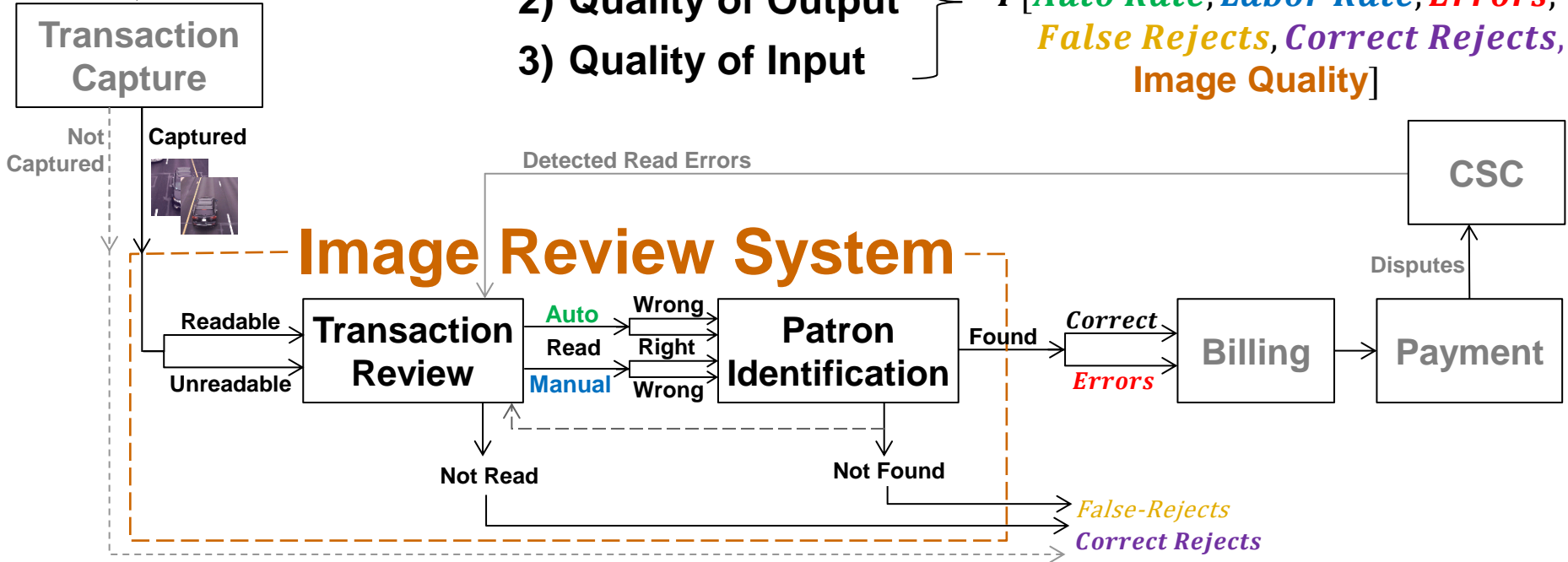## (619) 723-9894

Video Toll Collection Process

Three Cost Drivers:

    1) Manual Labor

    2) Quality of Output

    3) Quality of Input

$$OPEX \rightarrow$$
$$F[\textit{Auto Rate}, \textit{Labor Rate}, \textit{Errors},$$
$$\textit{False Rejects}, \textit{Correct Rejects},$$
$$\textbf{Image Quality}]$$

Manual Labor & Output Quality Cost Model

$$OPEX/Video\ Transaction =$$

$$(1 - \underline{Automation\ Rate}) \times (\underline{Avg.\ Labor\ Cost/Manually\ Reveiwed\ Transaction})$$

$$+$$

$$(\underline{Correct\ Reject\ Rate} + \underline{False\ Reject\ Rate} + 4 \cdot \underline{Error\ Rate}) \times (\underline{Avg.\ Revenue/Video\ Transaction})$$
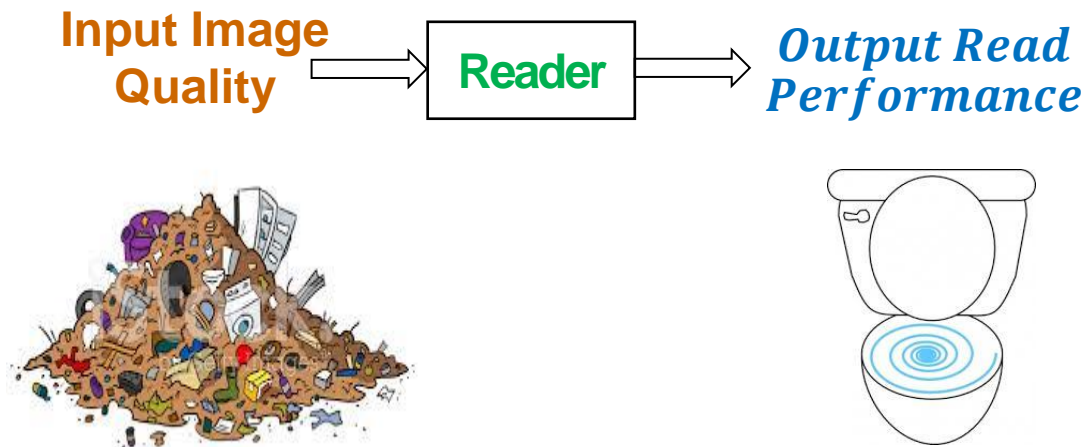
Goal: Specify achievable <u>Performance Levels</u> that reduce overall OPEX

Common RFP Spec: 90% *Automation Rate* at 0.5% *Error Rate* and 0.25% *False-Reject Rate*

$4M/yr Less Cost: 70% *Automation Rate* at 0.05% *Error Rate* and 0.1% *False-Reject Rate*

Self Evident that Input Image Quality Affects Plate Reading Performance

Input Image Quality → **Reader** → *Output Read Performance*

How to Quantify Image Quality & Its Cost to Operations?

Many Different Aspects of Image Quality Affect Plate Readability

Dirty, Scratched, Faded, Bent

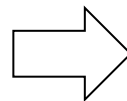
Obstructed

Viewing Angle Skew

Image Quality definable in terms of multiple quantifiable measures:

    Sharpness
    Resolution
    Contrast-to-noise
    Color Balance/Vitality

Out-of-Focus, Motion Blur, Low Resolution

Glare, Glint, Overexposure

Noisy, Black Clipped Underexposure

Readability depends on a complex interplay between IQ values across the plate

Acceptable quality often defined as imagery that is accurately readable
(when properly displayed to a competently trained reader)

Image Quality ⟺ Image Readability

Reader Performance forms the basis of the Definition of Image Quality

Image Quality Measure

A single measure that quantifies the impact to plate readability caused by all variations in plate condition and image-formation issues present across a representative distribution of imagery processed by a competently trained reader

No Machine Reader can accurately read plates across the entire range of image quality variations that a trained human can

(CAPTCHAs)

Human Readable ⇏ Machine Readable ⇒ Human Readable (if properly displayed)

Machine Image Quality ≠ Human Image Quality

Relating Machine Image Quality to Readability

Operational Automation Rate $\stackrel{\text{def}}{=}$ **(# of Txns automatically read)/(Total # of Txns input to Automation System)**

$$= \left(\frac{\text{\# of Txns automatically read}}{\text{\# of Txns that meet Machine IQ Req's}} \right) \times \left(\frac{\text{\# of Txns that meet Machine IQ Req's}}{\text{Total \# of Txns input to Auto System}} \right)$$

Qualified Automation Rate   **Machine Image Quality Rate**

Machine IQ Req's = Reasonable set of Restrictions to Human Readable Images necessary for license plates to be potentially Machine Readable with high accuracy

- **Images of a State/Plate-Style that automation is required/trained to read well**
- **Legible plate images where key information is not obfuscated or damaged**
- **Plate images whose quantifiable traits (sharpness, resolution, contrast/noise) are within practically achievable ranges that support accurate machine readability**

Automating the Measurement of Image Quality

Image Quality Definition

A single measure quantifying the impact to plate readability caused by the variations in plate condition and image-formation issues seen in a representative set of imagery processed by a competently trained OCR

Regularly re-calculated from Live Transactions

Measured over the same common plate style

Obtained from a representative set of plate & image-formation issues seen during live operation

OCR performance resulting from variations in image quality that deviate from Baseline quality

$$\text{Machine Image Quality Rate} = \frac{Operational\ OCR\ Read\ Rate\ [same\ plate\ style]}{Qualified\ OCR\ Read\ Rate\ [trained\ plate\ style]}$$

Formula independent of automation approach

Pre-calculated from OCR Acceptance Test data

Measured only over the most common plate style that the OCR is accurately trained to read

Contractually accepted OCR performance tested across a representative Baseline of images that were manually verified as possessing machine readable Image Quality variations

If Machine Readable ⇒ Human Readable (if properly displayed)

Takeaways

$$OPEX/Video\ Transaction =$$

$$(1 - Operational\ Automation\ Rate) \times (Avg.\ Labor\ Cost/Manually\ Reveiwed\ Transaction)$$

$$+$$

$$(Correct\ Reject\ Rate + False\ Reject\ Rate + 4 \cdot Error\ Rate) \times (Avg.\ Revenue/Video\ Transaction)$$

$$Operational\ Automation\ Rate = Machine\ Image\ Quality\ Rate \times Qualified\ Automation\ Rate$$

$$Machine\ Image\ Quality\ Rate \approx \frac{Operational\ OCR\ Read\ Rate\ [same\ plate\ style]}{Qualified\ OCR\ Read\ Rate\ [specific\ plate\ style]}$$

Understanding and Applying these Formulas to Tune an Agency's Image Review System can save Millions in operational $$$ each year