# LaTeX Code Generation from Equation Photograph

## Jim Brewer and James Sun
### Department of Electrical Engineering, Stanford University

## Motivation

LaTeX is a powerful typesetting system that is extremely useful for technical documents, in particular mathematical equations. However, once rendered, the output cannot be modified without access to the underlying code. Re-coding lengthy equations is time consuming and prone to error. This project allows a user to take a photograph of a printed equation and produce LaTeX markup code to generate the equation.

$$Q(z) = \frac{1}{\sqrt{2\pi}} \int_{z}^{\infty} e^{\frac{-x^2}{2}} dx$$

```
Q(z)=\frac{1}{\sqrt{2\pi }}\int\limits_{z}^{\infty }e^{\frac{-x^{2}}{2}}d x
```

## Future Work

- Extract equations from page or surrounding text
- Improve binarization and correct detection percentage
- Improve Skew Detection
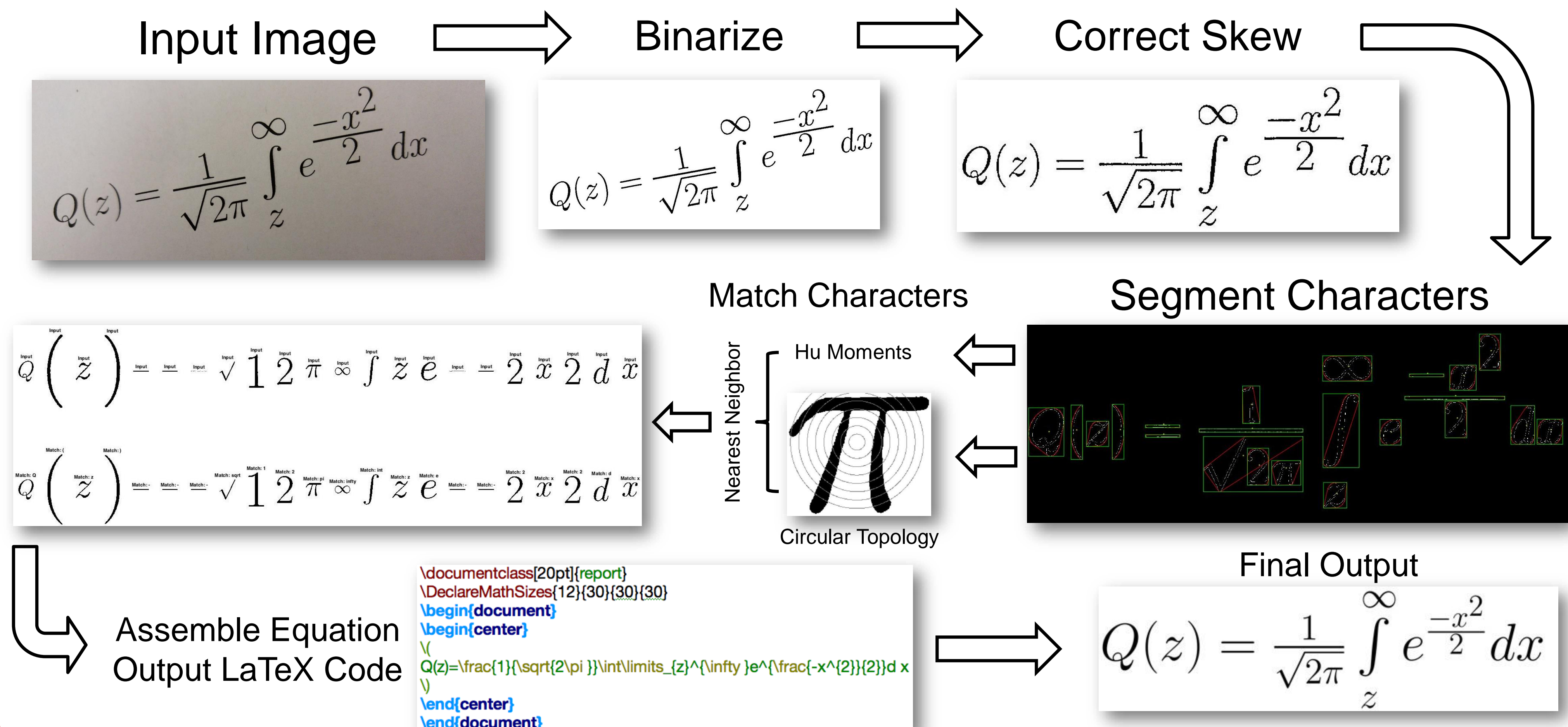- Recognize handwritten equations

## Related Work

[1]    Torres-Mendez, L.A.; Ruiz-Suarez, J.C.; Sucar, L.E.; Gomez, G., "Translation, rotation, and scale-invariant object recognition," in *Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on* , vol.30, no.1, pp.125-130, Feb 2000

[2]    Potocnik, B., "Assessment of Region-Based Moment Invariants for Object Recognition," in *Multimedia Signal Processing and Communications, 48th International Symposium ELMAR-2006 focused on* , vol., no., pp.27-32, June 2006

[3]    Kaur, Mandip, and Simpel Jindal. "An integrated skew detection and correction using fast fourier transform and dct." in *International Journal of Scientific & Technology Res, vol.*2, issue 12, Dec 2013

## LaTeX Code Generation Pipeline

Input Image → Binarize → Correct Skew

Match Characters ← Segment Characters

Hu Moments

Nearest Neighbor

Circular Topology

Assemble Equation Output LaTeX Code

```
\documentclass[20pt]{report}
\DeclareMathSizes{12}{30}{30}{30}
\begin{document}
\begin{center}
\(
Q(z)=\frac{1}{\sqrt{2\pi }}\int\limits_{z}^{\infty }e^{\frac{-x^{2}}{2}}d x
\)
\end{center}
\end{document}
```

Final Output

$$Q(z) = \frac{1}{\sqrt{2\pi}} \int_{z}^{\infty} e^{\frac{-x^2}{2}} dx$$

## Experimental Results

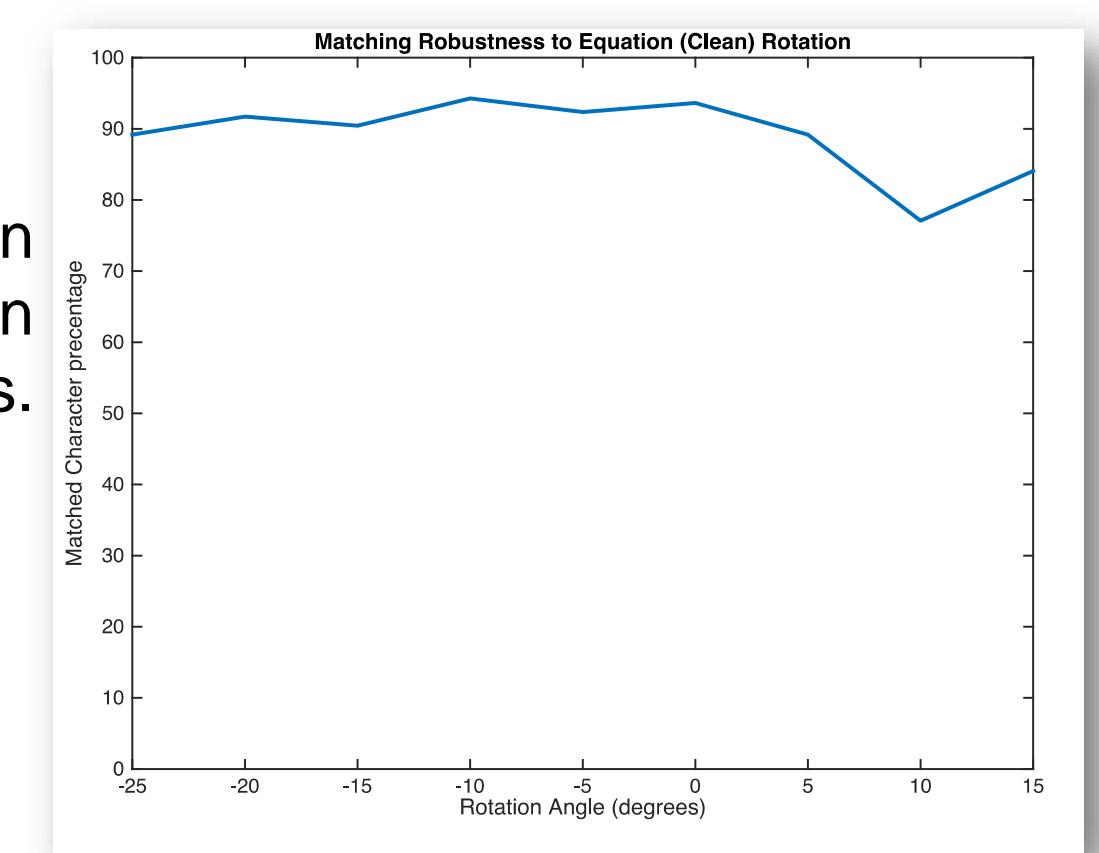| Scale | # Correct | % Correct |
|-------|-----------|-----------|
| 0.5 | 96 | 81.4% |
| 0.75 | 109 | 92.4% |
| 1.0 | 118 | 100.0% |
| 1.25 | 114 | 96.6% |
| Total: | 437 | 92.6% |

Resize each palette character by the corresponding scale and then attempt to match the character with the matching system using the original template.

Character Palette

$a\ b\ c\ d\ e\ f\ g\ h\ i\ j\ k\ l\ m$
$n\ o\ p\ q\ r\ s\ t\ u\ v\ w\ x\ y\ z$
$A\ B\ C\ D\ E\ F\ G\ H\ I\ J\ K\ L\ M$
$N\ P\ Q\ R\ U\ V\ W\ X\ Y\ Z$
$\alpha\ \beta\ \gamma\ \delta\ \epsilon\ \varepsilon\ \zeta\ \eta\ \theta\ \vartheta\ \iota\ \kappa\ \lambda$
$\mu\ \nu\ \xi\ \pi\ \rho\ \sigma\ \tau\ \upsilon\ \phi\ \varphi\ \chi\ \psi\ \omega$
$\Gamma\ \Delta\ \Theta\ \Lambda\ \Pi\ \Sigma\ \Upsilon\ \Phi\ \Psi\ \Omega\ 1\ i\ m$
$+\ *\ -\ /\ \int\ \infty\ \sqrt{}\ .\ \rightarrow\ !\ <$
$\approx\ \neq\ (\ )\ [\ \{\ \}$
$0\ 1\ 2\ 3\ 4\ 5\ 6\ 7\ 8\ 9$

Rotate 15 clean equations in increments of 5 degrees then segment and match characters.

Matching Robustness to Equation (Clean) Rotation

| Test (# of Eq) | Characters Correct | % Correct |
|----------------|--------------------|-----------| 
| Clean Eq. (15) | 147/157 | 93.6% |
| Eq. Pictures, Deskew1 (10) | 91 / 123 | 74.0% |
| Eq. Pictures, Deskew2 (10) | 98/123 | 79.7% |
| Eq. Pictures, Combined (10) | 106/123 | 86.2% |

Test matching on clean equation images and photographs of equations, tested with 2 deskewing methods.