Using Artificial Intelligence for Planning and Imposition

Tyler Thompson | Tilia Labs Inc.
TAGA - Spring 2020
Tyler Thompson  
Tilia Labs Inc.

ABOUT ME

- B.S. Degree Clemson University | Graphic Communications (2012)
- M.S. Degree Denver University | Information Systems (2019)
- Esko-Graphics | Sales (2012-2018)
- Tilia Labs Inc. | Director, Solutions (2018-Present)
- InterTech Award Recipient | 2019 (True-AI)
- Based in Charleston, South Carolina
INTERTECH TECHNOLOGY AWARDS

- Printing Industries of America (non profit trade association)
- World’s largest graphic arts trade association
- Honors the development of innovative technologies in Graphic Arts

2019 RECIPIENTS

- Tilia Labs | True-AI
- HP PageWide True Water-Based Inks
- HP PrintOS Color Beat
- Kodak Flexcel NX Ultra Solution
- Canon Solutions America
- Hybrid Software Hybrid VDP

Judge’s Comments

“Real AI used at an appropriate point and in an appropriate way. Game changing in that you could submit a design and it could go right to print without anyone else touching it!”
About Tilia Labs
About Tilia Labs

SOFTWARE COMPANY
- Software company founded in April 2012
- Based in Ottawa, Canada
- Small highly skilled development team
- Agile development process, short release cycles
- Over 500 licenses sold YTD
- Global distribution in over 32 countries

PRODUCTS
- tilia Phoenix
- tilia Griffin
- tilia Aries
- tilia Cloud

Customer Markets

- Packaging: 39%
- Labels: 23%
- Commercial: 16%
- Sign & Display: 21%
DeepFace
Facebook

AlphaGo
Google

ADAS
LG & Mercedes
ARTIFICIAL GENERAL INTELLIGENCE
- AI learns like a human
- Humans tagged millions of photos
- AI began recognizing patterns  
  \textit{Process = Convolutional Neural Networks}
- With more advanced training, AI understands context
Human pathologists:

- 300 slides per day
- 1 slide per minute
- 50,000 cells per slide
- Error rate between 10-15%
Machine pathologist:

- 30,000+ slides per day
  1 slide per second

- 0.6% error rate

- Can work alongside its human counterpart to close error rate to 0%
By 2020, artificial intelligence will create more jobs than it eliminates!

More Facts

- $2.9 Trillion business value by 2021!
- One in 25 CEO have deployed AI!
- 31% say they plan to in < 12 months!
- 72% of CEOs adopting AI deem it a “competitive advantage”!

$2.9 Trillion business value by 2021

Source: 2018 Gartner, Inc
How is AI being used in planning?
Human Planning

- Manual process (rubber cement)
- 2-3 days of production planning
- 1 day of CAD work
- 1 hour to impose a template
Let’s Plan a Job!

<table>
<thead>
<tr>
<th># of sheets</th>
<th># of forms</th>
<th># up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totals</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sku 1
Qty: 50,000
C,M,Y,K

Sku 2
Qty: 25,000
C,M,Y,K,186

# of sheets = 9
# of forms = 9
...is this the most optimized form?

<table>
<thead>
<tr>
<th>Sku</th>
<th>Qty</th>
<th>C,M,Y,K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sku 1</td>
<td>50,000</td>
<td>C,M,Y,K</td>
</tr>
<tr>
<td>Sku 2</td>
<td>25,000</td>
<td>C,M,Y,K,185</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th># of sheets</th>
<th># of forms</th>
<th># up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totals</td>
<td>10,000</td>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>

* 20% overage on SKU 2
...or this?

<table>
<thead>
<tr>
<th></th>
<th># of sheets</th>
<th># of forms</th>
<th># up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totals</td>
<td>9,375</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

*Additional press run/clean-up, save sheets
### What About Nesting?

<table>
<thead>
<tr>
<th>Sku 1</th>
<th>Qty: 50,000</th>
<th>C,M,Y,K</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th># of sheets</th>
<th># of forms</th>
<th># of sheets</th>
<th>press time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Totals**

<table>
<thead>
<tr>
<th># of sheets</th>
<th># of forms</th>
<th># of sheets</th>
<th>press time</th>
</tr>
</thead>
</table>
# Result Using Lay Flat

### Sku 1

- **Qty:** 50,000
- **C,M,Y,K**

### Table

<table>
<thead>
<tr>
<th># of sheets</th>
<th># of forms</th>
<th># up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totals</td>
<td>8,334</td>
<td>1</td>
</tr>
</tbody>
</table>
Result Using Shape

<table>
<thead>
<tr>
<th></th>
<th># of sheets</th>
<th># of forms</th>
<th># up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totals</td>
<td>5,556</td>
<td>1</td>
<td>9</td>
</tr>
</tbody>
</table>
Let’s Plan More!

<table>
<thead>
<tr>
<th>Sku</th>
<th>Qty</th>
<th>C,M,Y,K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sku 1</td>
<td>50,000</td>
<td>C,M,Y,K</td>
</tr>
<tr>
<td>Sku 2</td>
<td>20,000</td>
<td>C,M,Y,K</td>
</tr>
<tr>
<td>Sku 3</td>
<td>15,000</td>
<td>C,M,Y,K</td>
</tr>
<tr>
<td>Sku 4</td>
<td>12,000</td>
<td>C,M,Y,K,130</td>
</tr>
<tr>
<td>Sku 5</td>
<td>25,000</td>
<td>C,M,Y,K,184</td>
</tr>
<tr>
<td>Sku 6</td>
<td>12,500</td>
<td>C,M,Y,K,186</td>
</tr>
<tr>
<td>Sku 7</td>
<td>90,000</td>
<td>C,M,Y,K,186</td>
</tr>
<tr>
<td>Sku 8</td>
<td>80,000</td>
<td>C,M,Y,K,O,G</td>
</tr>
<tr>
<td>Sku 9</td>
<td>25,000</td>
<td>C,M,Y,K,186</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th># of sheets</th>
<th># of forms</th>
<th># up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totals</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>
### Planning Variables

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>13</strong></td>
<td><strong>2000</strong></td>
<td><strong>25</strong></td>
</tr>
<tr>
<td>SKUs</td>
<td>Quantities</td>
<td>Presses</td>
</tr>
<tr>
<td><strong>10</strong></td>
<td><strong>5</strong></td>
<td><strong>500</strong></td>
</tr>
<tr>
<td>locations</td>
<td>Stocks</td>
<td>Dies</td>
</tr>
<tr>
<td><strong>12</strong></td>
<td><strong>10</strong></td>
<td><strong>25</strong></td>
</tr>
<tr>
<td>Colors</td>
<td>Plates</td>
<td>Finishing</td>
</tr>
<tr>
<td><strong>12</strong></td>
<td><strong>8</strong></td>
<td><strong>5</strong></td>
</tr>
<tr>
<td>Offset</td>
<td>Flexo</td>
<td>Digital</td>
</tr>
</tbody>
</table>

Over 45,000,000,000 possible combinations!
Why is this important?

PACKAGING TRENDS

- During 2016 some 40,000 CPG products came to market, more than twice as many as in 1998
  - Led by smaller private-label/Tier 2
- Suave now has eight times as many unique SKUs as it had in 2007
- There is now a greater variety of labels in shorter run lengths than ever before

PRINTER/CONVERTER CHALLENGES

- Shorter run lengths
- Increase number of SKU’s
- Faster turn-around
- Decrease costs

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Figure 2
SKU proliferation case study: Suave has 8 times as many SKUs in 2017 as it did in 2007

Source: L.E.K. analysis

https://www.lek.com/insights/ei/strong-winds-driving-packaging-demand
Introducing: Imposition AI

The industry’s first artificially intelligent planning algorithm
TECHNOLOGY - HOW IS AI USED?

- AI algorithms leveraged in our Plan tool
- Intelligently navigate potentially huge search spaces of possible plans
- AI algorithms using both offline and online training
  - **Offline**: Allows Plan to choose the best algorithms and hyperparameters to use by classifying incoming jobs using models that were previously trained using existing customer and home-grown jobs.
  - **Online**: Occurs while application is running and the success of the planning algorithms/hyperparameters becomes known in the "real world"
Why employ AI to help?

MAIN CHALLENGES FACED

- Lookup tables/brute force is slow
- Hard coded equations are too rigid
- Generating individual layouts is computationally expensive
  - CPU time is scarce!
- True-shape nesting with free rotation
  - Infinite search space
- Need to support all segments of the printing industry from business cards to billboards, wide-format to folding carton
WHAT DOES GOOD LOOK LIKE?

- Offline models used to select algorithms and algorithm-specific hyperparameters
- Used to prioritize which plans to try to generate (i.e. reduce CPU time)
- Utilize customer examples and home-grown jobs
- Faster planning times and consistently higher quality results
Intelligent Searching
ONLINE LEARNING

- Occurs while Phoenix is running to determine the success or failure
  - Results become known in the "real-world"
- Reinforcement learning techniques adapt the models
- Mutates toward results quickly even with complex nested jobs
- Dynamically adjust for unexpected scenarios not well represented in offline training sets
Comparative Analysis

WITH AI & ML ALGORITHMS (Phoenix 7.0 circa 2019)
  Time: 1 second | Results: 672

NO AI & ML ALGORITHMS (Phoenix 3.3.2 circa 2015)
  Time: 11 seconds | Results: 209

1100% Speed Increase
One more time... 1/10 speed

WITH AI & ML ALGORITHMS (Phoenix 7.0 circa 2019)
Time: 1 second | Results: 672
1100% Speed Increase

NO AI & ML ALGORITHMS (Phoenix 3.3.2 circa 2015)
Time: 11 seconds | Results: 209
## Folding Carton Case-Study

*Folding carton converter approximately $50MM revenue per year*

<table>
<thead>
<tr>
<th></th>
<th>Items Per Month</th>
<th>Average # Up</th>
<th>Change Over Cost</th>
<th>Down Time Per Month (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual</td>
<td>2,000</td>
<td>2.1</td>
<td>$277,867</td>
<td>1,333</td>
</tr>
<tr>
<td>With Phoenix</td>
<td>2,000</td>
<td>2.52</td>
<td>$231,556</td>
<td>1,111</td>
</tr>
<tr>
<td><strong>Net Savings (per month)</strong></td>
<td></td>
<td></td>
<td><strong>$46,311</strong></td>
<td><strong>222 hrs</strong></td>
</tr>
</tbody>
</table>

### Cost Variables

- **Average Change Over (hours):** 1.4
- **Hourly Rate of Press:** 208.4
- **Net Savings:** $46,311
## Folding Carton Case-Study

*Folding carton converter approximately $50MM revenue per year*

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<td>1,111</td>
</tr>
<tr>
<td><strong>Net Savings</strong></td>
<td></td>
<td></td>
<td><strong>$555,733</strong></td>
<td>2,667 hrs</td>
</tr>
</tbody>
</table>

### Cost Variables

- **Average Change Over (hours):** 1.4
- **Hourly Rate of Press:** 208.4

Folding Carton Case-Study
Press-side Planning

- Just-in-time is challenging
- Predicting demand is nearly impossible
- Imposition AI enables JIT planning at the press
- Operators can ask Phoenix for jobs approaching a due date and Phoenix returns imposed jobs
Artificial Intelligence is here.
Are you ready?