ViDX: Visual Diagnostics of Assembly Line Performance in Smart Factories

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Extended Marey’s graph

1885 as a visual depiction of train schedules.
- Train speeds,
- Dwell times,
- Directions of travel,
- Service frequency,
- Stop spacing

-● Train speeds,
-● Dwell times,
-● Directions of travel,
-● Service frequency,
-● Stop spacing

333,392 cars per year
460,338 cars per year
1 year = 525,600 minute

Cybersyn, Chile 1971–1973

Distributed decision support system designed by British operations scientist Stafford Beer.
- An operations room,
- Economic simulator,
- Custom software to check factory performance.
- Using national network of teleces.

requirements for historical data

R1: Facilitate the detection of abnormal processes.
R2: Inefficiencies and troubleshooting.
R3: Engaging users to detect outlier process interactively.
R4: Support predictive analysis.

requirements for real-time system

R5: Highlight abnormalities in real time.
R6: Visual metaphors.
R7: Interactive exploration of large amount of process data (thousands of products everyday).
R8: Visually indicating the problematic components in 3D model!!

Assembly line as a directed acyclic graph (DAG)

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Anomaly detection

the assembly line is stopped partially,
the entire assembly line is stopped by a line abnormal

Quantiles brush and Sample brush

Interactive outlier detection

Aggregation

visual exploration for:
- Troubleshooting
- Process optimization
- Decision making
- Identify inefficiencies and locate abnormalities in:
- Historical data
- Realtime assembly line performance.

requirements gathered through discussion with Managers and Operators?

Cybersyn opsroom image credit Gui Bonsiepe

Industry 4.0

1st
2nd
3rd
4th

Mechanisation, water-power, steam power
Mass production, assembly line, electricity, Computer and automation, Cyber Physical Systems

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Cybersyn opsroom image credit Gui Bonsiepe

Cybersyn opsroom image credit Gui Bonsiepe

Munzner, Tamara. [Munzner, Tamara.}
System architecture and implementation

Case study
Detect inefficiencies and troubleshooting:
- Schedule break
- Stop and restart for a few times before operating smoothly.

Limitations
- Data scalability:
  Site managers are willing to immediately know the abnormalities in each day in calendar visualization.
  Longer time span in Marey's graph:
  In displays with limited width, traces will become vertical lines.
- Subprocess and parallel processes are overlaid:
  Increasing the complexity of manufacturing process can cause visual clutter.

Suggestion
User can change the distance between stations based on average process time.
- Comparing lines with different length and slope (tilt).

Real-time monitoring
Radial graph proposed by target users.
Users asked for three layers of rotating concentric circles:
- Not effective
- New design

Critiques
- Every operation is trackable not every product.
There is no jump in production line and product will be stored in case of failure.
FIFO system can cause overall delay and disables abnormalities detection techniques.
- The angle channel is less accurately perceived than rectilinear spatial position channel.
- Data scalability:
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Critiques
- Application of Marey's graph in this domain was very effective.
- Two anomaly detection processes were suggested for outlier detection.
- System was tested with real data and they ran case studies for both historical data and real-time data.
- User interviews shows promising results but no evaluation.

Conclusion

Future directions
1. Deployment in real production line
2. Improve scalability
3. The occurrence of outliers in composite events

My suggestion:
- Extend the visualization to group or uncountable products
- Add indicators for sensors and their values in real time system and controllability for stations