

Examples of Al Applications in Brazil FEEC in the Past 30 Years (and a Look at the Future)

Fernando Gomide School of Electrical and Computer Engineering University of Campinas Campinas, SP, Brazil

EADCA 2022, DCA, FEEC

Outline

Our (engineering) view of AI Early applications Current/future applications

Our (engineering) view of Al



Early applications

- Control systems
- Real-time railroad meet-and-pass scheduling
- Iron ore stockpiling planning in shipping yards
- Oil recovery
- Thyroid hormone profiling
- Blending and fat formulation

Current/future applications

Real-time rail movement planning Last mile supply chain planning Intelligent railroad yard management Robot-based compact storage-retrieval Adaptive real-time flight control

Early applications

Control systems: process control



The Pattern Recognition Approach

Proc. 27th IEEE Conference on Decision and Control, December 1988



Pattern Characterization



Self-Tuning Controller in the Loop



Elevator Group Control



RTKP in supervisory control systems.

IEEE Trans. on Knowledge and Data Engineering, vol. 8, no. 1, 1996



g. 5. Wait time \times call—R.B. strategy.



g. 7. Wait time \times call—Conventional strategy.



Ricardo R. Gudwin is a PhD candidate at the State University of Campinas (UNICAMP), Campinas, São Paulo, Brazil. He received the BS degree in electrical engineering from the State University of Campinas (UNICAMP), in 1989, and the MS degree in electrical engineering/automation from the same university in 1992. His topics of interest include artificial intelligence, fuzzy systems, neural networks, evolutive systems, and cognitive sciences. He is currently working in his PhD thesis on methods of learning for knowledge processing.

(Fuzzy) Traffic Control



Block diagram of the Fuzzy Traffic Controller

Proc. 2nd IEEE Int. Conference on Fuzzy Systems, San Francisco, March 1993



Intersection of the Brasil avenue with Reboucas avenue



Traffic flow volume along the day



José Roberto Favilla, FEE, Unicamp, BS1982, MS 1988. Currently global leader for Industry 4.0 at IBM in applying advanced analytics, optimization, AI, IoT and Blockchain technologies to drive innovation.

Fuzzy air Conditioning



https://www.mozartleiloeiro.com.br/peca.asp?ID=8602685#





Ricardo Loureiro, FEEC, BS 1989, MS 1996. Currently Director of Citrix, worked for more than 20 years in several multinational technology companies (Whirlpool, Motorola, Microsoft). His career is a combination of technology and business in supply chain and engineering in Brazil and Latin America. He developed several products, processes, and business transformation mechanisms.

(Fuzzy+Inverter) Air conditioning



Fonte: arquivo Rodrigo Almeida Gonçalves



Rodrigo Almeida Gonçalves, Turma 1990(94) EC-FEEC



Railroad crew scheduling



Direct allocation algorithm

Proc. IFAC Control in Transportation Systems, Braunschweig, June 2000



| camento : DIA | AS TAVARES - 01/4 | Ago/2022 a 31/Ago/ | 2022 | | | | | | | | | Sur Line | MRS |
|--|---|---------------------|--------------|---------------|----------------|-----------------------|-------------|--------------------------------|--------------|--|------------------------------------|-----------|------------------------|
| E | 1 Gerenciament | o de períodos | | τ | 2 Definição da | is tarefa | IS | 3 Progra | mação diária | 4 PDF | 5 Programação Oncional | | |
| quencial de ta | Equipes e pré-aloca arefas | ação | 8 Solicitaçã | es e datas no | bres | | 2 90 | onfiguração do algoritmo de al | осаção | 10 Sequencial | 11 Geração de escala | 12 RH | 6 Equipes padrão |
| | в с | D | E | F | G | | | Eco Ativo | Pacco 1 | Nome 1 | | | |
| . 4 PD0 | 2.3 3.2 | 4.1 | 5.0 | 6.0 | 7.4 | ~ | * | 55 | 1 | SERGIO HIPO | OLITO MAGALHAES | Nome 2 | |
| 01:30 | PRC (| 09:30 PRE | 05:30 | FUL 11:30 | PRO 03:00 | | | 53 🗸 | 3 | RONALDO FE | RNANDES SILVA FILHO | | Ê |
| 55 | 4 | 53 | 45 33 | 11 | 40 | | 7 | 45 🗹 | 4 | PETERSON M | ENDES DA SILVA | | |
| 8.3 | 9.2 10. | .1 11.0 | 12.0 | 13.5 | 14.4 | | | 33 | 5 | LUCIANO ALV | /ES GOMES | | Contract of the second |
| PRF | PRO | PRF FOL | FOL | PRO | PRF | | 00 | | 6 | PALLO GERSO | N CORREA BARROS | | and an owner the state |
| | 11:30 | 07:30 | 13:30 | 05:30 | | | | 22 | 8 | FLAVIO OTTO | NI BATISTA | | |
| 22 | 12 | 16 | 36 19 | 52 | 3 | | M.M. | 12 🗸 | 9 | ELIERTE GONZ | ZAGA | | |
| 15.3 PR0 | 16.2 17 PRF 17 | .1 18.0 FES FOL | 19.5 PR0 | 20.4 PRF | 21.3 PR0 | - | | 16 | 10 | FABIO ALEXAN | IDRE OLIVEIRA DOS SANTOS | | |
| 17:30 | | 00:0 | 0 13:30 | | 21:30 | | ត្ត | 36 | 11 | MARCELO LEAM | NDRO DA SILVA | | |
| 3 | 9 20 | 44 | 7 5 | 26 | 35 | | 23 | 15 | 12 | EMERSON MOR | DA STLVA | | |
| 22.2 | 23.1 2 | 4.0 25.5 | 26.4 | 27.3 | 28.2 | | ma | 52 | 13 | ALEVANDOE OU | ETDO7 MODETDA | 1 | ~ |
| PRF | FES | FOL PRU | PRE | 23:30 | FRE | | ~ | < | | | | | 9 |
| | 10 22 | 18 | 24 8 | 1 | 27 | | ~~ | | | Desminite | Hora de apresentação Dia da semana | Número de | e fundonários |
| 20.1 | 30.0 3 | 31.5 32.4 | 33.3 | 34.2 | 35.1 | | * | # Cod | go | MAN DATTO KM 460 (0) | ITodos os dias | | 1 ~ |
| FES | FOL | PRO PRF | FES | PR0 07:30 | PRE | | \$ | 1 M11 | | MAN PATIO KM 460 (0) 1 | 5:00 Todos os dias | | 1 |
| The state of the s | 00:00 | 19:30 | | 3 | 60 | | | 2 3 M11 | | MAN PATIO KM 460 (0) 10 | 6:00 Todos os dias | | 1 |
| | 23 56 | 20.3 | 40.2 | 41.1 | 42.0 | | Folga | 4 M11 | | MAN PATIO KM 460 (0) 16 | 6:00 Todos os dias | | 1 |
| 36.0 FOL | FOL | PRO PR | F PRO | PRF | FOL 05:00 | | FE/9x | 5 M12 | | MAN PMV EM LAFAIET 06 MAN PMV EM LAFAIET 07 | 7:00 Todos os dias | | 1 |
| 03:3 | 09:30 | 01:00 | 09:00 | | 2 49 | - | 11 | 6 M12 | | MAN PMV EM LAFAIET 07 | :00 Todos os dias | | 1 |
| and the state | 34 38 | 59 | 50 47 2 | 48.1 | 49.0 | | 4+ | 8 M12 | | MAN PMV EM LAFAIET 14 | :00 Todos os dias | | 1 |
| 43.0 | 44.5 PP0 | 45.4 46.3 PRF PP | 0 PRF | FES | FOL | | ++ | 9 M12 | | MAN PMV EM LAFAIET 15: | -on Todos os días | | 1 |
| 11: | 00 03:30 | 15 | :00 | | 2 47 | | | 10 M12 | | MAN PAT, DO MURTIN 07: | 00 Todos os dias | | 1 |
| | 51 25 | 19 | 42 4 | 1 55 0 | 56.2 | No. | | 11 M13 | | MAN PAT. DO MURTIN 07: | 00 Todos os dias | | I |
| 50.5 | 51.4 | 52.3 53.2 RE2 R | 2 FES | FOL | PR0 | | 00 | 13 M13 | | MAN PAT. DO MURTIN 14: | 00 Todos os das | | 1 |
| PR 11 | 00 PRC | 19:30 19 | :30 | 00:00 | 2 59 | | C | 14 M13 | | MAN PAT. DO MURTIN 15:0 | 00 Todos os dias | | |
| 11 | 29 | 9 28 | 21 | 41 5 | - | | Z | 15 M13 | | MAN OFI. LOC. P1-7 (0) 06:3 | 30 Todos os días | 12:29 | |
| | and the second se | E CO 1 | 61.1 | 04.0 | | and the second second | 1.6 | 16 M21 | | and the second s | | PUS 13-32 | |

| æ | 1 | ୍ଦ - ସି 🛉 | Æ | | | | | | | | | | | | | M |
|--------------|----------------|------------------|---------------|-------------|----------------|--------------------|----------|--------------|---------------------|--------------|--------|-----------------|------------------------|---------------|--------|-----------------------|
| amento | DIAS TAVARE | S - 01/Ago/20 | 22 a 31/Ago/2 | 2022 | | | | | 0.00 | | | | | | | |
| | 1 Gerenc | iamento de pe | riodos | | τ | 2 Definição das ta | refas | | 3 Progra | mação diária | | PDE | 5 Programação Opcion | nal | 4 | 6 Equipes padrão |
| 43 | 7 Equipes e pr | é-alocação | | 8 Solicita | ções e datas n | obres | و 🏂 | Configuração | o do algoritmo de a | locação | 10 | Sequencial | 💋 11 Geração | o de escala | 12 RH | 13 Relató |
| vencial de | e tarefas | | | | - | | | - | | | | | | | | |
| | 8 | с | D | E | F | G | \$. | Eqp | Ativo | Passo 1 | | Nome 1 | | | Nome 2 | |
| 00 | 2.3 | 3.2 | 4.1 | 5.0 | 6.U | 7.4 | <u> </u> | 55 | | 1 | 1 | SERGIO HIP | POLITO MAGALHAES | | | |
| : 30 | PRE | 09:30 | FRE | 05:30 | 11:30 | 03:00 | 14 | 53 | | - | 3 | RONALDO F | ERNANDES SILVA FILHO | | | |
| 51 | 4 | 53 | 4 | 33 | 11 | 40 | | 45 | | - | 4 | PETERSON | MENDES DA SILVA | | | |
| | 9.2 | 10.1 | 11.0 | 12.0 | 13.5 | 14.4 | | 33 | | | 5 | EDDEX 200 | LVES GOMES | | | _ |
| æ | PRO | PRF | FOL | FOL | PRO | PRF | 00 | 40 | | | 7 | PALLO GER | SON CORREA BARROS | | | |
| | 11:30 | | 07:30 | 13:30 | 00:30 | | | 22 | | | 8 | FLAVIO OTT | TONI BATISTA | | | |
| 22 | 12 | 15 | 31 | 10.5 | 20.4 | 3 | du du | 12 | | | 9 | ELIERTE GO | INZAGA | | | |
| RO | PRF | FES | FOL | PRO | PRF | PRO | | 16 | | | 10 | FABIO ALEX | ANDRE OLIVEIRA DOS SAN | TOS | | 1 |
| 7:30 | 20072255 | | 00:00 | 13:30 | | 21:30 | | 36 | | | 11 | MARCELOL | EANDRO DA SILVA | 0000 | | |
| 39 | 20 | 44 | 7 | 5 | 26 | 35 | 0 | 15 | | 1 | 12 | EMERSON M | IOREIRA DE OLIVEIRA | | | |
| 2 | 23.1 | 24.0 | 25.5 | 26.4 | 27.3 | 28.2 | ma | 52 | | | 13 | ROMULO JO | DSE DA SILVA | | | |
| range - | TES | 80:00 | 15:30 | IN | 23:30 | THE | | Ċ | | | | the Prove the | | | | |
| 40 | 30.0 | 31.5 | 32.4 | 33.3 | 34.2 | 35.1 | | | c | ódigo | Descri | ;ão | Hora de apresentação | Dia da semana | | Número de funcionário |
| ES | FUL | 19:30 | PHO. | FES | PR0 07:30 | PRF | | 1 | (M) | 11 | MAN P | ATIO KM 460 (0) |) 08:00 | Todos os dias | | |
| | 50.00 | 17.30 | 20 | 10 | 21 | 60 | - | 2 | M | 11 | MAN P | ATIO KM 460 (0) |) 15:00 | Todos os dias | | |
| 6. | 37.1 | 38.4 | 39.3 | 40.2 | 41.1 | 42.0 | Folga | 3 | M | 11 | MAN P | TIO KM 460 (0) |) 16:00 | Todos os dias | | |
| OL | FOL | PRO | PRF | PRO | PRF | FOL | | 4 | M | 1 | MAN P | ATTO KM 460 (0) |) 16:00 | Todos os dias | | |
| 3:30 | 09:30 | 01:00 | 24 | 09:00 | 1 100 | 85:00 | FE/9X | 6 | M | 12 | MAN P | VEMLAFAIET | 07.00 | Todos os dias | | |
| 34 | 38 | 59 | 50 | 2 | 37 | 49 | ++ | 7 | M | 12 | MAN P | V EM LAFAIET. | 07:00 | Todos os dias | | |
| OL | 44.5 PR0 | 45.4 PRF | 46.3 PR0 | 47.2 PRF | 48.1 FES | FOL | | 8 | M | 12 | MAN P | WEM LAFAIET. | 14:00 | Todos os dias | | |
| 1:00 | 03:30 | | 15:00 | | | 00:00 | ++ | 9 | M: | 12 | MAN PI | IV EM LAFAIET. | 15:00 | Todos os dias | | |
| 51 | 25 | 19 | 47 | 48 | 13 | 47 | 111 m | 10 | M | 12 | MAN PI | IV EM LAFAJET. | 15:00 | Todos os dias | | |
| 22 | 51.4 | 52.3 | 53.2 | 54.1 | 55.0 | 56.2 | | 11 | M: | 13 | MAN P | AT. DO MURTIN | 07:00 | Todos os dias | | |
| KU • 00 | PRE | RE2 19:30 | 19:30 | FES | PUL 00:00 | 13:00 | 00 | 12 | M | 13 | MAN P | T. DO MURTIN | 07:00 | Todos os dias | | |
| | 20 | 20 | 21 | 41 | 57 | 5.9 | E | 14 | M | 13 | MAN P | T. DO MURTIN | 15:00 | Todos os dias | | |
| 1 | 58.0 | 59.2 | 60.1 | 61.0 | 62.0 | | | 15 | MI | 13 | MAN P | T. DO MURTIN | 15:00 | Todos os dias | | |
| PRF | FOL | PRO | PRF | FOL | FOL | | B | 16 | MS | 21 | MANO | FL LOC. P1-7 (| 0) 06:30 | Todos os dias | | |

| 🕯 Sigem FD | T Seg 1/Ago | | | | | | | | | | | | | | |). | |
|------------------------------|------------------------|--------------------------|---------------|------------------|--------------|--------------------|--------------|-----------------|------------------|-----------------|------------------|-----------------|-----------------|------------------|-----------------|-----------------|--------------------|
| Arquivo Cont | figuração Hel | p | | | | | | | | | | | | | | | - total |
| | A 10 | ୍ -ଶ୍ଚି 🙀 | E | | | | | | | | | | | | | | MR |
| estacamento : | DIAS TAVARES | - 01/Ago/2022 | a 31/Ago/2022 | | | | | | a | | | | | | | | |
| | 🔂 1 Gerencia | mento de perío | dos | | τ 20 | efinição das tarei | fas | 6 | 3 Programaçã | io diária | 4 PDE | | 5 Programação | Optional | | 6 Equipes | padrão |
| 43 | 7 Equipes e pré | -alocação | - | 8 Solicitações e | datas nobres | 5 | 🔍 9 Cont | iguração do alg | oritmo de alocaç | ão | 🏢 10 Seqü | encial | 00 11 G | ieração de escal | 12 R | н 🕼 | 13 Relatórios |
| Gerando uma Funcionário : | nova escala | | | | | | | | Parceiro : | | | | | | | | |
| Selecionado | Horas notu | Horas diur | Pernoites | Tempo Desc. | Pegadas | Categoria | Sex 29/Jul | Sab 30/Jul | Dom 31/Jul | Seg 1/Ago | Ter 2/Ago | Qua 3/Ago | Qui 4/Ago | Sex 5/Ago | Sab 6/Ago | Dom 7/Ago | Seg 8/Ago |
| | 0.00 84.00 84.00 | 0.00 204.00 204.00 | 2 | 16.42 | 12 | Maquinista | RET 12:06 | FES | PR1 06:30 | 35 PRF | 36 FOL 02:30 | 37 FOL 08:30 | 1 PR1 00:30 | 2 PRF | 3 PR1 08:30 | 4 PRF | 5 FOL ^ |
| | 0.00 81.50 81.50 | 0.00 206.50 206.50 | 2 | 16.42 | 12 | Maquinista | FER 00:00 | FER 00:00 | TRN 00:00 | 36 FOL 02:30 | 37 FOL 08:30 | 1 PR1 00:30 | 2 PRF | 3 PR1 08:30 | 4 PRF | 5 FOL 04:30 | 6 FOL 10:30 |
| | 0.00 97.50 97.50 | 0.00 214.50 214.50 | 3 | 15.79 | 13 | Maquinista | F0L 00:00 | PR1 21:30 | FES | 21 PR1 22:30 | 22 PRF | 23 FES | 24 FOL 00:00 | 25 PR1 16:30 | 26 PRF | 27 FES | 28 PR1 02:30 |
| | 0.00 80.00 80.00 | 0.00 208.00 208.00 | 1 | 16.42 | 12 | Maquinista | FES | PR1 18:30 | FES | 17 PES | 18 FOL. 00:00 | PR1 12:30 | PRF | 21 PR1 22:30 | 22 PRF | 23 FES | 24 FOL 00:00 |
| | 0.00 97.00 97.00 | 0.00 215.00 215.00 | 2 | 15.79 | 13 | Maquinista | FER 00:00 | FER 00:00 | TRN 00:00 | RET 16:30 | FES | 18 FOL 00:00 | 19 PR1 14:30 | 20 PRF | 21 PR1 22:30 | 22 PRF | 23 FES |
| | 0.00 0.00 0.00 | 0.00 0.00 0.00 | 0 | 24.0 | 0 | Maquinista | AFD 07:59 | AFD 07:59 | AFD 07:59 | AFD 00:00 | MFD 00:00 | AFD 00:00 | AFD 00:00 | AFD 00:00 | AFD 00:00 | AFD 00:00 | AFD 00:00 |
| | 0.00 86.00 86.00 | 0.00 202.00 202.00 | 2 | 16.42 | 12 | Maquinista | FOL 00:00 | PR1 14:30 | FES | 2 PRF | 3 PR1 08:30 | 4 PRF | 5 FOL 04:30 | 6 FOL 10:30 | 7 PR1 04:30 | 8 PRF | 9 PR1 12:30 |
| | 0.00 71.00 71.00 | 0.00 129.00 129.00 | s | 18.74 | 21 | Maquinista | RE3 15:00 | FES | FES | FOL. 00:00 | M26 15:00 | H26 23:00 | N26 23:00 | FES | FOL 00:00 | M26 23:00 | H26 23:00 |
| | 0.00 97.50 97.50 | 0.00 206.50 206.50 | 3 | 16.0 | 14 | Maquinista | FER 00:00 | FER 00:00 | TRN 00:00 | PRO 11:30 | PRF | 5 FOL 05:30 | 6 FOL 11:30 | 7 PRO 03:00 | 8 PRF | 9 PR0 11:30 | 10 PRF |
| | 0.00 63.50 | 0.00 218.50 | i | 16.58 | 13 | Maquinista | PR0 23:30 | FES | FES | 30 FOL 00:00 | 31 PRO 19;30 | 32 PRF | 33 FES | EX01 00:00 | RET 05:30 | 35 FOL 03:30 | 37 FOL 09:31 |
| * | | Ð | C | | 00 | 0 | 3 | ЩO | | 8 | Í | ţ, | វ៉ា 🔢 | | 1 | <u>88</u> 88 | 22 |
| | > | Ø | 14 | | | ų. | | | | RH | Pré | D | Ł | ĩ | 1 | 8 | DA. |
| م I | T | e | 0 | 1 | - | | | | 201 | | | | | ^ | 📾 🌈 d× | POR 13:3 | 9 2022 Q |



Rodrigo Gonçalves, FEEC, Unicamp, BS 1994, MS 1997, PhD 2000. Currently CTO at Nitryx Progress Rail applying advanced analytics, optimization, AI, DSS and technology driven driven innovation.

Real-time train scheduling













15% increase daily ore volume transportation1.6 litters fuel/1000 metric tons ore transportedHelpers maneuvers speed-up on steep rampsReal-time operation started end of 1995

Smart oil recovery





Stockpiling in iron ore shipping yard















| 👹 Propatio R25 - 02/06/2001 | | - 0 × |
|------------------------------------|---|-------|
| Mandatórias Ajuste do | o estado Refresh | |
| | | |
| Time 🖉 🗗 | Maquinas | |
| PM | Cod | |
| 09:50 | EP2 N S Ociosa Ociosa | |
| 01/Jun/2001 | EP3 N S Ociosa - | |
| 📋 Navios | | |
| Navio Pi Embarqui | ue Ini Té Ca Ca Ca Ca | |
| LYRA 1 2001 / 0563 | 339 001 * R* * A | |
| HUTA 1 2001/0538 | 387 🗖 Pátio | ľ₫, |
| SOLID 2 2001/0542 | | |
| RUTLA 1 2001/0545 | 459 E 70.0 65.0 50.0 55.0 50.0 45.0 40.0 35.0 30.0 25.0 ∠20.0 15.0 10.0 5.0 | |
| DOCEL 2 2001/0021 | | a |
| | | |
| | 70.0 55.0 50.0 55.0 50.0 45.0 40.0 35.0 30.0 25.0 20.0 15.0 10.0 5.0 | |
| r 🗂 Trens 👘 🥢 | FRD IFRD 1 339 23MH9 SMH7 SMHA SPLO SMH8 PFCJ PPL2 PPL2 NCCJ SMH2 | |
| Codigo Hora | | |
| 1 11:28 01/Jun | n/21 70.0 55.0 50.0 55.0 50.0 45.0 40.0 35.0 30.0 25.0 20.0 15.0 10.0 5.0 | |
| 2 11:48 01/Jun 3 13:30 01/Jun | n/2 NCCJ NCCJ FCGU SFCJ SMHA SSH6 PPL2 PPL2 SML2 S6CL SSP3 FCED | |
| 4 13:50 01/Jun | | - |
| 5 18:12 01/Jun | n/2 70.0 65.0 60.0 55.0 50.0 45.0 40.0 35.0 30.0 25.0 20.0 15.0 10.0 5.0 | |
| 6 18:32 01/Jun | n/2 MP13 MP15 MG73 SPL0 PCGU PCGU PCPU NACJ PCS3 PCPE PCS3 SSP4 SSH6 | |
| 7 18:52 01/Jun 8 19:11 01/Jun | | 2 |
| 9 19:31 01/Jun | | - |
| 10 20:43 01/Jun | n/2 FCBD FCBD SFCJ SFCJ SFCJ S0F2 SMH6 SFCJ SHL2 SMH6 SHRMH3 SMH4 FCPE FCPE | |
| 11 21:03 01/Jun 12 23:11 01/Jun | $\frac{n/2}{r}$ F 70.0 55.0 50.0 55.0 50.0 45.0 40.0 35.0 30.0 25.0 20.0 15.0 10.0 5.0 | 7 |
| 13 00:00 02/Jun | n/2 | |
| 14 23:31 01/Jun | n/2 | |
| 15 00:58 02/Jun | n/2 | |
| | | |
| | | |
| | | |
| ř | | |



Paulo Molck, Turma 1995 EC-FEEC, MS 2001

Thyroid hormone profiling







Proc. IFSA/NAFIPS 2001

| Apoio a decis | são - [Inferências] | | | | | | | | |
|-------------------------------|--|--|--|--|--|--|--|--|--|
| - Eim Grupos Tabelas fuzzy | Visoes Inferencia Janelas Inferência | | | | | | | | |
| Granulaiização | Endocrinologia Quimica Clinica Aids LIPIDICO TIROIDE HORMONIO TIREOESTIMULANTE T3 T4 T4 LIVRE TESTE DE ESTIMULO COM TRH PARA DOSAGEM DE TSH TESTE DE ESTIMULO C/ TRH PARA DOSAGEM DE TSH TESTE DE ESTIMULO C/ TRH PARA DOSAGEM DE T3E TSH TESTE DE ESTIMULO C/ TRH PARA DOSAGEM DE T3E TSH | Visão T3; T3;T4;T4L; T3;T4;T4L;TSH; T3;T4;T5H; T3;T4L;TSH; T3;T4L;TSH; T4;T4L;TSH; T4;T4L; T4;T4L;TSH; T4;T4L;TSH; T4L;TSH; T4L; T4L;TSH; T5H; | | | | | | | |
| | * NORMAL | | | | | | | | |
| | # toh Normal and t4 Normal and t3 Normal and t4I Normal then toh Libera and t4 Libera and t3 Libera and t4I Libera | | | | | | | | |
| | IF TSH Normal AND T4 Normal AND T3 Normal AND T4L LimiteSuperior THEN TSH Libera AND T4 Libera AND T3 Libera AND T4L Libera | | | | | | | | |
| | IF TSH.PoucoAlto and t4.Normal and t3.Normal and t4I.Normal then tsh Libera and t4.Libera and t3 Libera and t4I Libera | | | | | | | | |
| | IF TSH PoucoAlto AND T4 Normal AND T3 Normal AND T4L LimiteSuperior THEN TSH Libera AND T4 Libera AND T3 Libera AND T4L Libera | | | | | | | | |
| Simulações | * BAIND if tsh Baixo and 14 Alto and 13 Alto and 141 Alto then tsh Libera and 14 Libera and 13 Lit | bera and MLLibera | | | | | | | |
| Auditoria Controle | if tsh MuitoBaixo and 14 Alto and 13 Alto and 141 Alto then tsh Libera and 14 Libera and | 113 Libera and 141 Libera | | | | | | | |

17,500 results reviewed during testing

Disagreements: system judged worth reviewing, but the expert did not

Real-time operation started on May 2000

341,000 patients results checked

Blending and fat formulation





| | | | SFC ^a | (%) | | |
|------------------|-------|-------|------------------|-------|------|--------|
| | 10°C | 20°C | 25°C | 30°C | 35°C | 37.5°C |
| Sample 1 | | | | | | |
| Required | 43.24 | 24.14 | 18.52 | 12.66 | 5.08 | 2.83 |
| Network estimate | 40.30 | 24.00 | 18.50 | 12.10 | 4.90 | 2.90 |
| Experimental | 40.66 | 23.83 | 18.19 | 12.35 | 5.55 | 2.85 |
| Sample 2 | | | | | | |
| Required | 32.90 | 19.32 | 12.60 | 9.94 | 4.44 | 2.52 |
| Network estimate | 33.30 | 19.30 | 14.60 | 9.20 | 3.70 | 2.10 |
| Experimental | 33.64 | 19.22 | 14.18 | 9.19 | 3.72 | 2.31 |
| Sample 3 | | | | | | |
| Required | 26.23 | 17.29 | 11.82 | 7.22 | 3.16 | 1.23 |
| Network estimate | 26.00 | 15.80 | 12.20 | 7.60 | 3.00 | 1.70 |
| Experimental | 26.04 | 16.29 | 12.05 | 8.09 | 3.08 | 1.41 |
| Sample 4 | | | | | | |
| Required | 29.95 | 14.54 | 9.87 | 4.41 | 0.18 | 0.00 |
| Network estimate | 29.40 | 14.60 | 10.20 | 6.10 | 2.40 | 1.40 |
| Experimental | 29.94 | 14.96 | 10.04 | 6.18 | 2.60 | 1.20 |
| Sample 5 | | | | | | |
| Required | 22.80 | 14.26 | 8.98 | 4.62 | 1.89 | 1.38 |
| Network estimate | 23.20 | 12.30 | 8.80 | 5.30 | 2.10 | 1.20 |
| Experimental | 23.71 | 12.76 | 8.82 | 5.20 | 1.80 | 0.83 |
| Sample 6 | | | | | | |
| Required | 35.02 | 22.68 | 14.51 | 8.14 | 3.42 | 1.85 |
| Network estimate | 35.50 | 19.60 | 14.60 | 9.10 | 3.70 | 2.10 |
| Experimental | 36.22 | 20.12 | 14.61 | 9.30 | 3.77 | 2.20 |
| Sample 7 | | | | | | |
| Required | 37.52 | 22.60 | 18.23 | 10.60 | 4.01 | 1.98 |
| Network estimate | 38.00 | 22.80 | 17.60 | 11.40 | 4.60 | 2.70 |
| Experimental | 38.56 | 22.95 | 17.26 | 11.25 | 4.66 | 2.64 |
| Sample 8 | | | | | | |
| Required | 32.29 | 20.99 | 13.32 | 7.00 | 3.06 | 1.65 |
| Network estimate | 33.50 | 17.40 | 12.60 | 7.70 | 3.10 | 1.80 |
| Experimental | 34.27 | 17.84 | 12.32 | 7.74 | 3.16 | 1.81 |

Verification of the Neural Network Formulating Commercial Products



IFSA 1995 São Paulo

Current/future applications

Real-time movement planning



Last mile supply chain



Railroad yard management



Robot-based compact ASRS





Adaptive real-time control





Acknowledgments

My professors and under/graduate class mates at IPUC/PUC-MG FEEC/UNICAMP CWRU/USA My colleagues of FEEC and UNICAMP The under and graduate students of FEEC and UNICAMP



Special thank to



Márcio L. Andrade Netto received the ME degree in 1970 from the Technological Institute of Aeronautics (ITA), Brazil, and the MS and Doctor degrees in electrical engineering from the State University of Campinas in 1973 and 1976, respectively. He is now with the State University of Campinas (UNICAMP) in the Department of Computer Engineering and Industrial Automation, Faculty of Electrical Engineering. From 1985 to 1986, he was at the Technological Center for Informatics, Ministry of Science and

Technology, where he was head of the Manufacturing Automation Department. He has worked on large Brazilian projects such as the S. Paulo Metro System, and on international cooperative programs with Germany and, currently, with several Ibero-American countries. He is currently developing systems based on fuzzy logic and neural networks together with Brazilian industry. His research interests include neural networks and fuzzy systems and their applications to control and automation. Dr. Andrade is the coauthor of a book on industrial automation and holds a patent on induction motors. He is a member of the Brazilian Society for Automation (SBA).

IEEE Trans. on Knowledge and Data Engineering, vol. 8, no. 1, 1996