A CONTAINER TERMINAL MODELLING BASED ON MICRO-SCOPIC MULTI-AGENT DISCRETE EVENT SIMULATION

LUCAS CISTERNAS, STEFANO DE LUCA, ROBERTA DI PACE, AGOSTINO DI LUGGO, CHIARA FIORI

Transportation Systems Analysis Laboratory — Depart. Of Civil Engineering, University of Salerno, Italy

INTRODUCTION AND MOTIVATION

- The efficiency of a container terminal depends on human factors (workload).
- Enviromental footprint of container terminal needs attention.
- The development of a decision support tools is the need to: i) Simulate terminal operations at a micro-scopic level ; ii) Estimate the enviromental impacts for each type of handling means; iii) Take into account the impact of endogenous variables (fatigue) affecting the handling mean operators; iv) Take into account the "information flow" (intangible) in a container terminal.

GOALS

- Specification, calibration and validation of a multi-agent (microscopic) discrete event model in order to: 1) Simulate the impact of workload modelling; 2) Estimate the carbonfootprint caused by terminal activites.
- Application on real case study: the **Salerno Container Terminal**

CASE STUDY

PORT OF SALERNO

- Located in the Tyrrhenian Sea gulf in the southern Italy
- Plays an important role in the industrial and commercial system of the center-southern Italy

CONTAINER TERMINAL

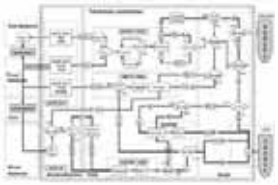
Cargo handling means:

- 4 Quay Crane
- 2 Bridge Crane
- 9 Reach Stacker
- 14 Tug Master

CONTAINERS TRAFFIC TERMINAL

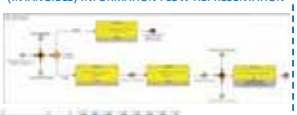
MODEL IMPLEMENTATION: SPECIFICATION, CALIBRATION, VALIDATION

SPECIFICATION

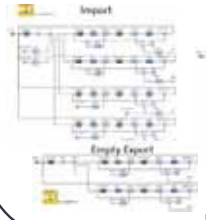


- FULL VS EMPTY
- 20'' vs 40''
- INFORMATION FLOW
- PERFORMANCE FUNCTION FOR EACH HANDLING MEAN
- ENVIROMENT PERFORMANCE FUNCTION

(INTANGIBLE) INFORMATION FLOW REPRESENTATION

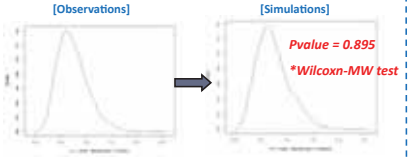


FLOW CHART

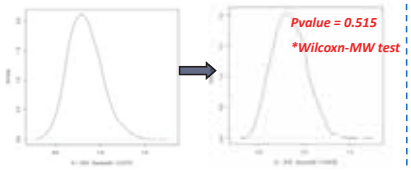


LOGICAL ARCHITECTURE IN AnyLogic

CALIBRATION [Observations] — VALIDATION [Simulations]



LOADING CONTAINER 20 FULL- GANTRY CRANE



UNLOADING CONTAINER 40 FULL-QUAY CRANE

- The Analysis have been carried out for all handling operations

OUTPUT

Model time: 1 week

Container traffic = 1680 TEU

Run	Distance TM [km]	Distance TR [km]	Working Time C [min]	Working Time RS [min]	CO2 Emision TM [kg]	CO2 Emision T [kg]	CO2 Emision C [kg]	CO2 Emision RS [kg]	CO2 Emision S [kg]
Run 1	976.3	11310.6	937.2	1995.5	915,8	7284,0	421,7	2245,0	203671,8
Run 2	976.2	11216.3	949.3	1971.8	915,7	7223,3	427,2	2218,3	202290,6
Run 3	976.4	9252.4	946.2	1832.6	915,9	5958,6	425,8	2061,7	204646,8
Run 4	976.3	10562.3	943.9	1915.0	915,8	6802,1	424,8	2154,4	203265,6
Run 5	976.3	8245.6	945.8	1733.6	915,8	5310,2	425,6	1950,3	202615,6
Run 6	976.3	11228.6	956.9	1981.3	915,8	7231,2	430,6	2228,9	202412,5
Run 7	976.3	10850.4	963.5	1946.4	915,7	6987,6	433,6	2189,7	202534,4
Run 8	976.4	10765.8	946.1	1906.8	915,8	6933,2	425,7	2145,2	199365,7
Run 9	976.3	10203.4	945.5	1894.2	915,7	6571,0	425,5	2131,0	204159,3
Run 10	976.3	10398.6	950.6	1903.2	915,8	6696,7	427,8	2141,1	202534,4
Mean	976.3	10403.4	948.5	1908.0	915,8	6699,8	426,8	2146,5	202749,7
Std. Dev.	0.1	974.2	7.3	78.1	0,1	627,4	3,3	87,9	1437,2

TM = Tug Master ; TR = Truck ; RS = Reach Stacker; C= Crane

SIMULATION SCENARIOS: RESULTS

ALTERNATIVE SCENARIO: [PATHS & TM ALLOCATION]

Trucks:

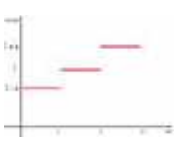
- travelled distance reduction by trucks: 26%
- CO_2 emissions reduction by trucks: 11%

	DistanceTM [km]	Distance TR [km]	Working Time Crane [min]	Working Time RS [min]	CO_2 Emissions TM [kg]	CO_2 Emissions TR [kg]	CO_2 Emissions C [kg]	CO_2 Emissions RS [kg]	CO_2 Emissions Ships [kg]
Scenario 0	976	10403	949	1908	916	6700	427	2147	202750
Scenario 1	1172	9259	1138	2461	1099	5963	512	2769	253437
Delta	+195	-1144	+190	+553	+183	-737	+85	+622	+50687
Delta %	+20%	-11%	+20%	+29%	+20%	-11%	+20%	+29%	+25%

Not Advisable!

FATIGUE ANALYSIS IN QUAY CRANE OPERATORS

Case 1—Step function

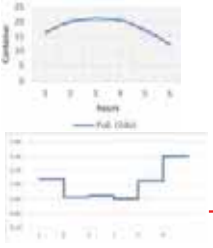


$\mu_{real} = \mu_1$

	Real (min)	Case 1 (min)
Run 1	236	240
Run 2	246	229
Run 3	237	244
Run 4	237	228
Run 5	243	234
Run 6	239	236
Run 7	244	234
Run 8	232	239
Run 9	234	238
Run 10	224	248
Run 11	230	234
Mean	237	237
Dev.Std	6	6

Replacing Gamma function with a simple Step function, the results of the simulations are similar

Case 2— Yerkes – Dodson



	Ship Time Real [min]	Case 2 [min]
Run 1	315	302
Run 2	316	301
Run 3	307	305
Run 4	300	302
Run 5	315	305
Run 6	311	306
Run 7	311	304
Run 8	315	306
Run 9	324	299
Run 10	311	310
Mean	312.5	304
Dev. Std	6.3	3

The handling times decrease in the first hours of the shift and increase at the end of the shift

Step Function VS Yerkes-Dodson

Results achived using the Step Function in case 2 are worse

CONCLUSIONS AND FUTURE RESEARCH

- The model proposed, developed in AnyLogic®, is able to correctly simulate 1 week of scheduling in about 70/80 seconds allowing for possible **real-time management of port activities**.
- The model is also flexible and can be used to simulate several scenarios in different port terminals.
- Regarding fatigue analysis further investigations are required.