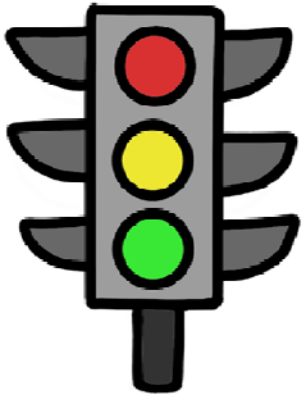
Heuristic based approach for Novosibirsk traffic light scheduling



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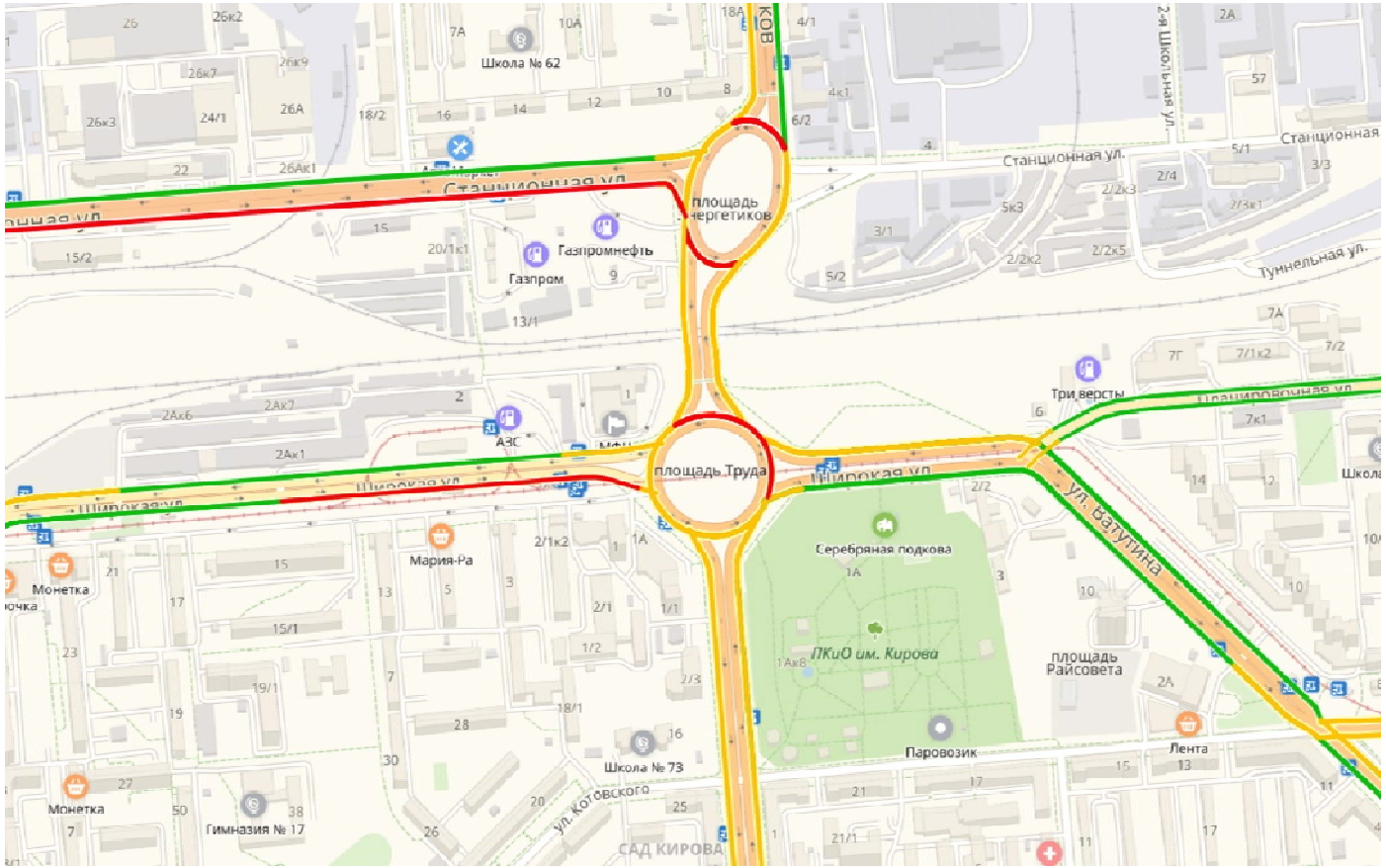
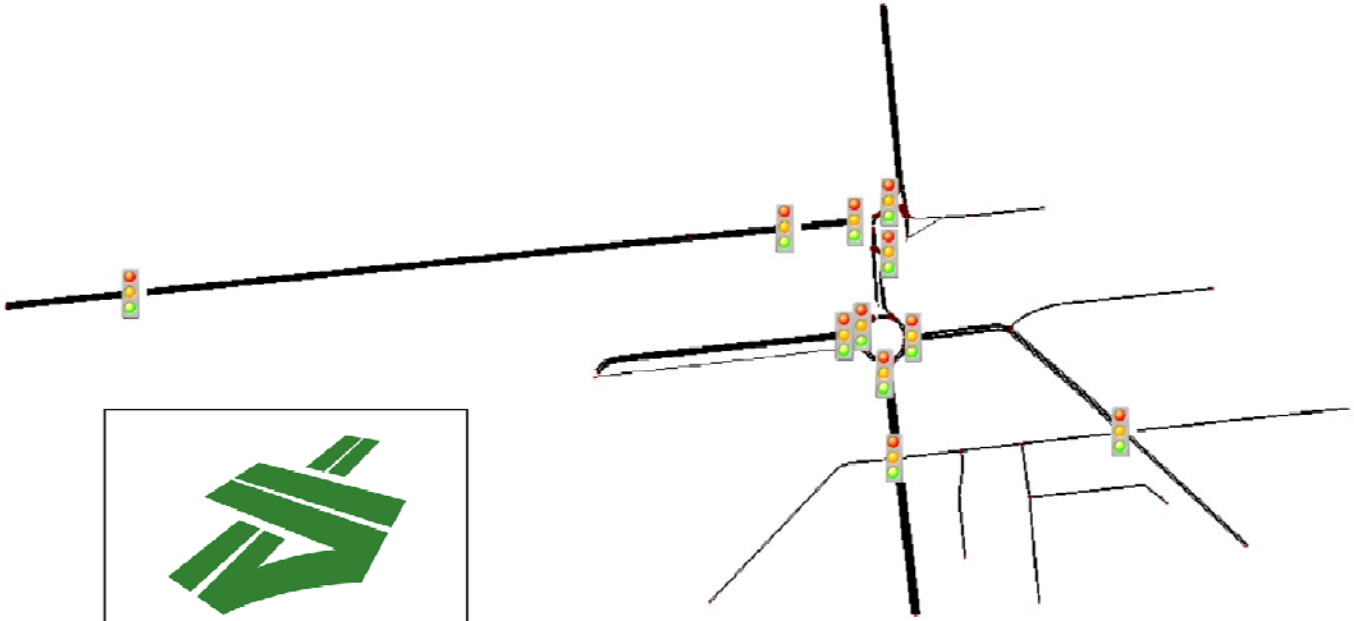
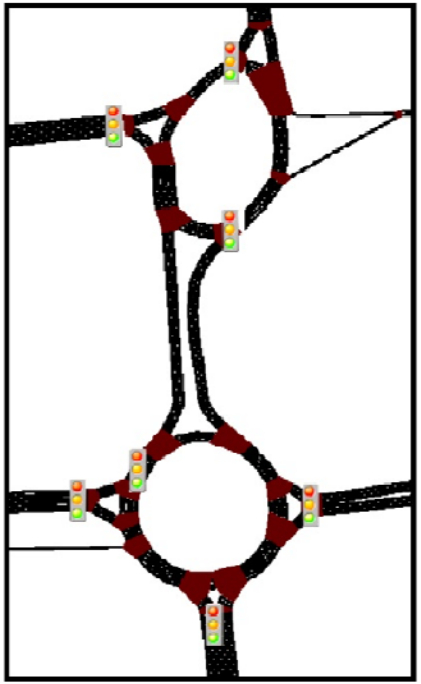
Introduction



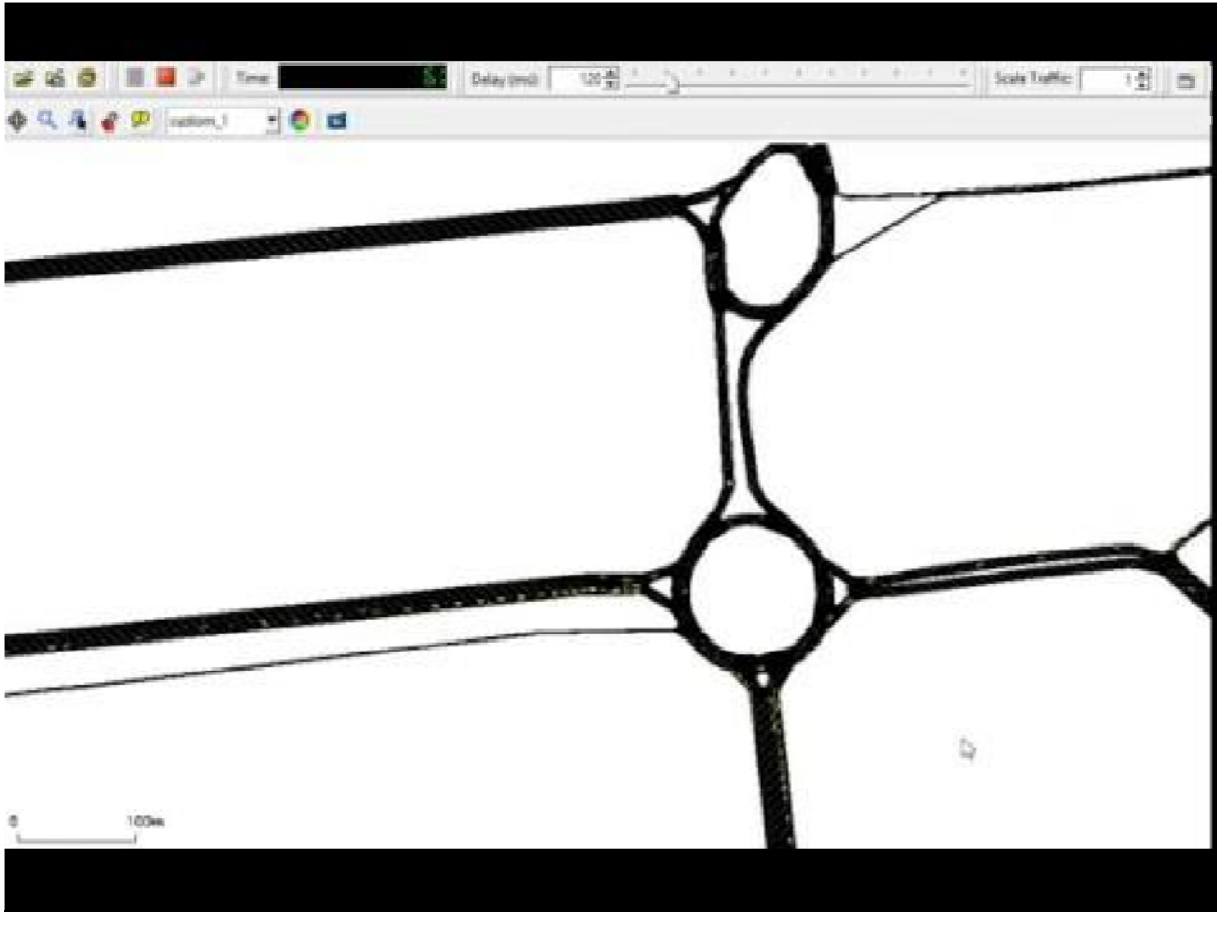
Simulation



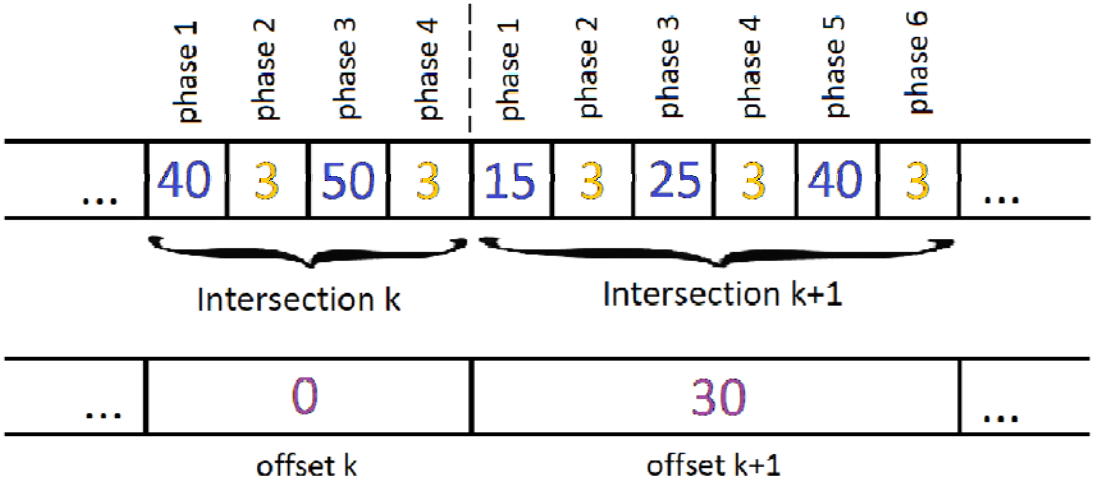


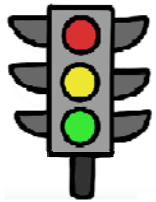
SUMO
SIMULATION OF URBAN MOBILITY

Simulation

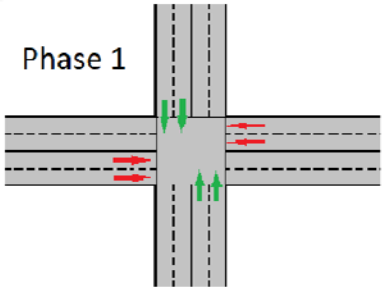


Solution representation

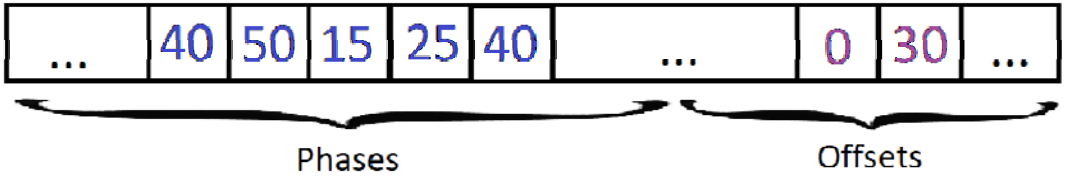




Phase 1: G G r r G G r r (40s)
Phase 2: y y y y y y y y (3s)
Phase 3: r r G G r r G G (50s)
Phase 4: y y y y y y y y (3s)



Solution encoding:

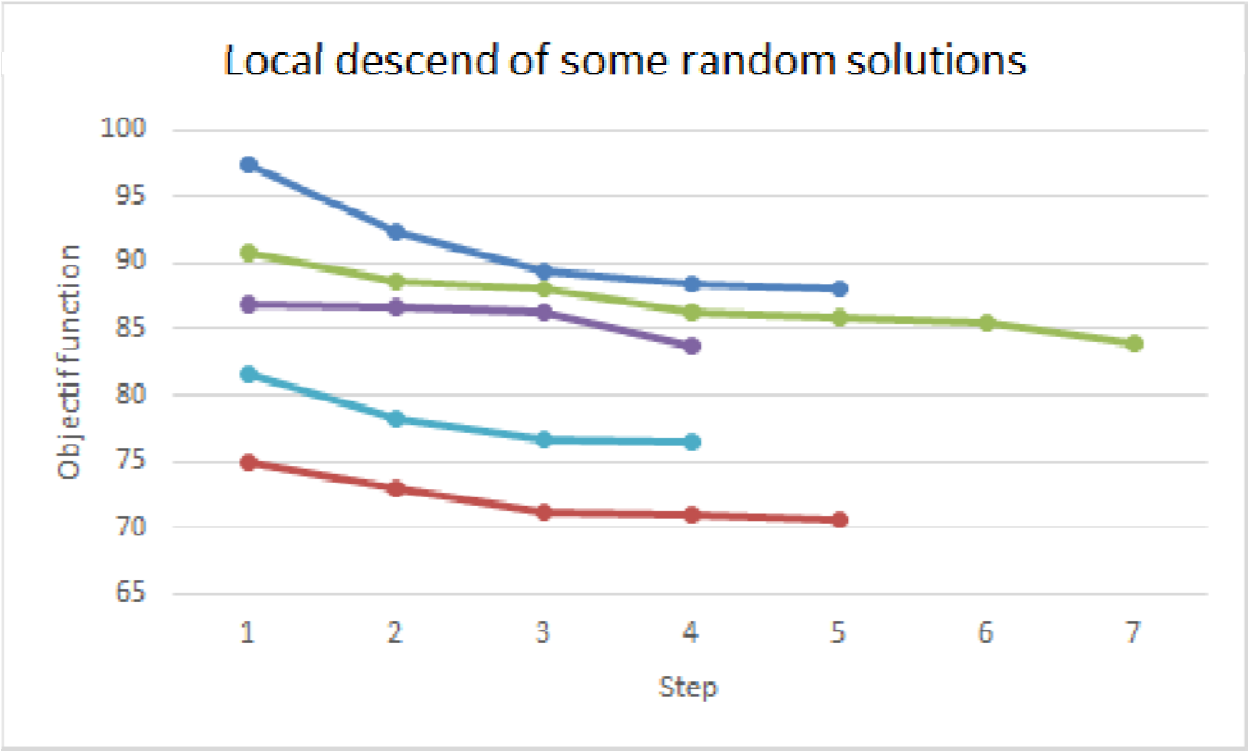


Genetic algorithm

Schema of genetic algorithm for minimization problem:

1. Chose an *initial population* $P = \{X_1, ..., X_k\}$ and keep a record value $f^* = \min f(X_i)$.
2. While *stop criterion* is not satisfied do the following:
   - Chose two *parents* X_{i_1} and X_{i_2} from population.
   - Apply a *crossover* operator to X_{i_1} and X_{i_2}, obtain a new solution X'.
   - Apply a *mutation* operator to X', obtain a new solution X''.
   - Doing a *local descend* from X'', obtain a new solution X'''.
   - If $f(X''') < f^*$, then update a record $f^* := f(X''')$.
   - Add X''' to population and delete the worst one.

Local descend



Objective functions

- Average time that the vehicles spent standing involuntarily (**Waiting time**)

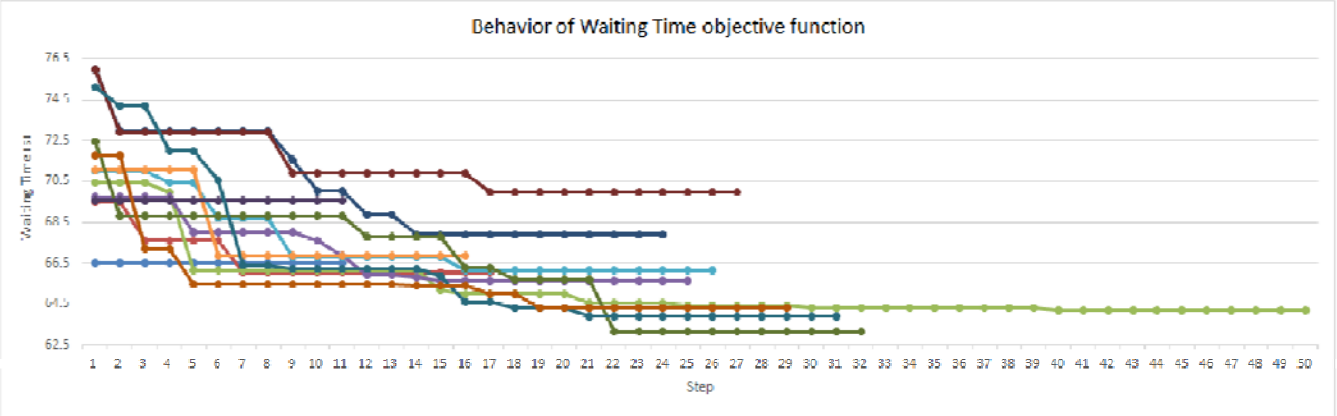
- **Average speed** of the vehicles entered to simulation (average route length divided by average trip duration)

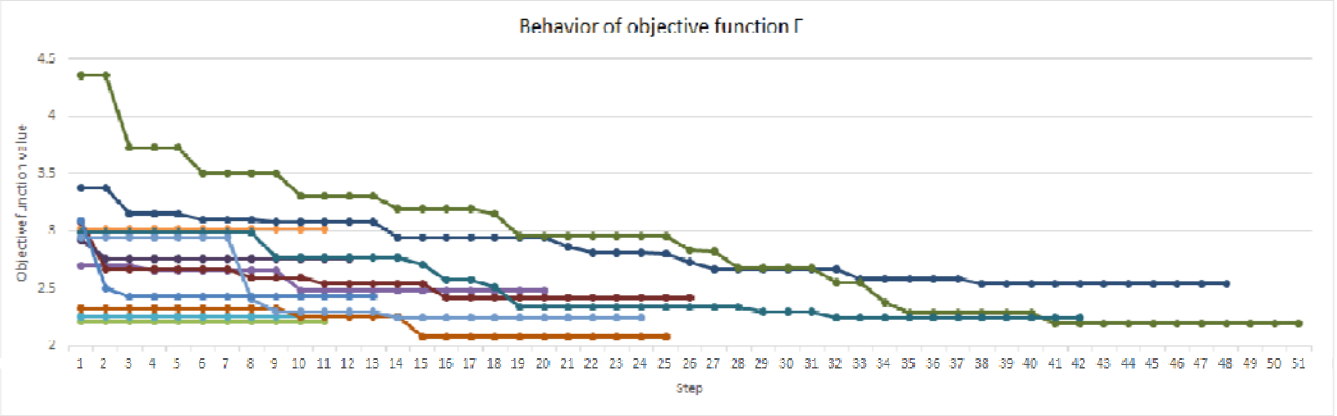
$$\boldsymbol{F} = \frac{TT + SW + (NV * ST)}{V^2 + P},$$

TT - global trip time,
ST - simulation time,
SW - the time vehicles were obliged to stop and wait,
V and NV - the numbers of vehicles that reached and did not reach their destinations resp.,
P expresses proportion of colors in each phase j of all the intersections i: $P = \sum_i \sum_j s_{ij} \frac{G_{ij}}{r_{ij}}$
with state duration s_{ij}, number G_{ij} of traffic lights in green and r_{ij} of traffic lights in red

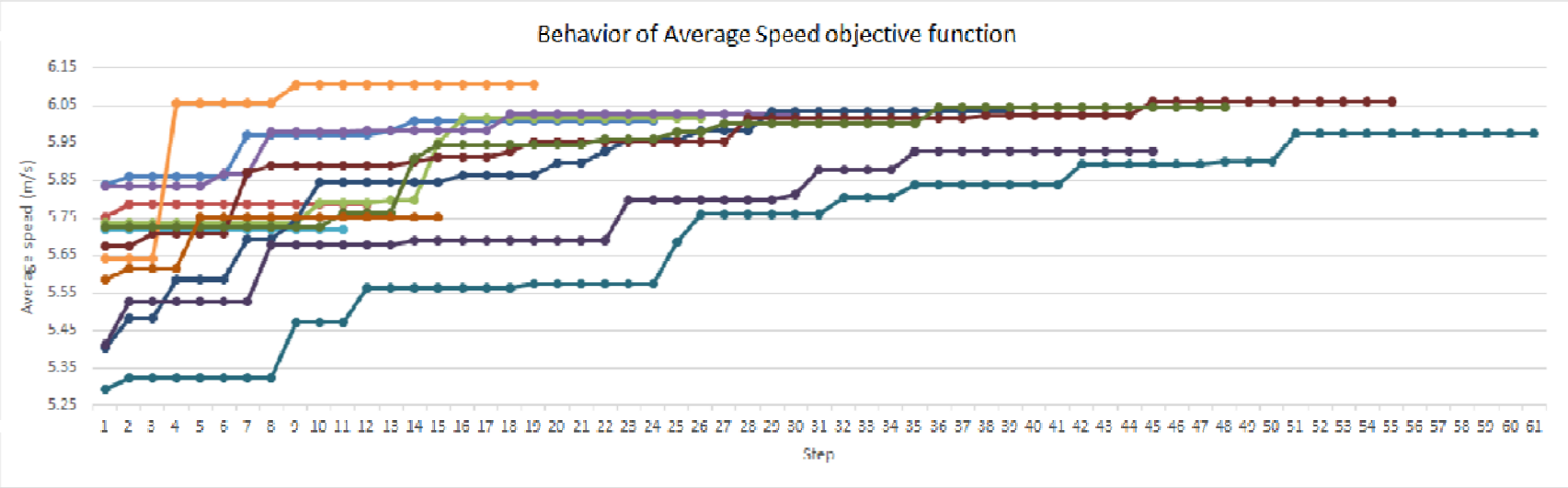
* J.García-Nieto, E.Alba, A.Carolina Olivera. *Swarm intelligence for traffic light scheduling: Application to real urban areas.* Engineering Applications of Artificial Intelligence, 2012.

Objective functions





Objective functions



Objective function	Waiting Time	Av. Speed	F
Solution with the best Waiting Time	**63.14**	5.87	14.40
Solution with the best Av.Speed	64.64	**6.11**	40.97
Solution with the best value of F	95.04	3.97	**2.08**

Parameters of the algorithm

Initial population:

- Random vectors
- Local optima (random vectors + local descend)

Parents selection:

- The best individual in population with some other random one.
- Two parents chosen under geometric distribution with p=0.3 from the population sorted in ascending order of objective function value.

Crossover operator:

- One of parents coordinates
- Random number between two parents coordinates
- Mean value of parents coordinates

Parameters of the algorithm

Initial population

Objective function	Waiting Time	Av. Speed	F
Initial population from random vectors	66.47	5.97	2.33
Initial population from local optima	65.91	5.94	2.49

Parents selection

Objective function	Waiting Time	Av. Speed	F
Leader and random	66.07	5.92	2.46
Geometric distribution	66.31	5.99	2.36

Crossover operator

Objective function	Waiting Time	Av. Speed	F
Random one	64.63	5.98	2.34
Random between	66.53	5.89	2.51
Mean value	67.41	6.00	2.38

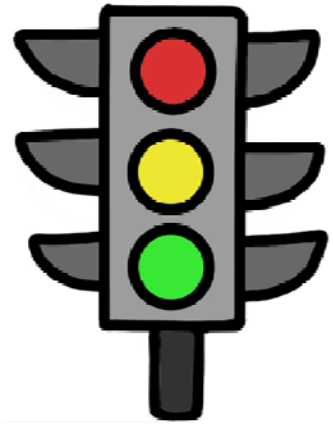
Population degeneration

Experiments set	Initial average distance	Average distance after 15th iteration	Final average distance
All	1190.41	669.12	422.27
Waiting Time obj.function	1174.69	640.98	378.13
Av.Speed obj.function	1206.64	661.23	379.70
Objective function F	1189.90	705.16	508.98
Init. popul. from local optima	1186.20	714.14	522.63
Random init. population	1194.62	624.11	321.92
Select leader and random	1193.87	701.97	451.69
Select under geom. distr.	1186.94	636.28	392.85
Crossover "random one"	1196.81	756.51	494.33
Crossover "random between"	1192.78	619.30	379.71
Crossover "mean"	1181.64	631.56	392.77

Final results

Fitness	Vehicles	Schedule	Algorithm
813	2462	[9, 60, 13, 30, 52, 29, 8, 22, 44, 20]	GA+LS
822	2448	[10, 60, 8, 36, 60, 39, 17, 42, 41, 27]	GA+LS
827	2443	[10, 60, 18, 25, 32, 18, 8, 42, 53, 25]	GA+LS
818	2450	[11, 60, 21, 22, 60, 33, 22, 43, 41, 26]	GA
819	2456	[8, 60, 24, 20, 55, 49, 8, 32, 46, 32]	GA
822	2459	[8, 60, 25, 19, 60, 38, 11, 60, 36, 25]	GA
1683	1822	[11, 22, 57, 33, 27, 37, 8, 40, 53, 29]	initial

Thank you for attention!



Any questions?