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Population-based metaheuristics for planning interval training sessions in mountain biking

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Agenda

Motivation

Computational intelligence in sports

- Stochastic population-based nature-inspired metaheuristics have recently revealed that they are a very robust tool for planning sport training sessions in various sports, e.g. running, cycling, triathlon.
- Until recently, no special attention was paid to planning interval training sessions, where the high-intensity intervals are followed by low-intensity periods of recovery.

Goals of this study

The main contributions of this study are summarized as follows:

- to elucidate the problem of planning the interval training sessions,
- to present planning the interval training sessions as an optimization problem,
- to propose a new method for particular problem that is based on the Bat Algorithm (BA),
- to apply the proposed algorithm on a real archive of collected interval training sessions.

Introduction

- Sport trainers are crucial components in the process of an athlete's sports training.
- Many efforts are required to become an excellent sport trainer, such as
  - experience,
  - knowledge,
  - pedagogical skills.
- Automated planning of the sport training sessions is still considered as a very challenging task.
- Artificial sport trainer is a recent effort in that direction.

Interval training

- Interval training was first popularized by the Olympic Champion Emil Zatopek in the 1950s.
- High-intensity intervals are interspersed with recovery periods.
- Aerobic interval training is defined as an interval training which elicits aerobic metabolism at a higher ratio than anaerobic metabolism.

An example of interval training: 1 to 8 minute runs at 90 % to 100 % speed of maximal oxygen uptake, with recovery of 2 to 3 minutes.

Problem definition 1/2

Total intensity of the interval training session is expressed as follows:

$$TRIMP(IT) = \sum_{j=1}^{n} \left(HR_{k_j}^{(I)} \cdot t_{k_j}^{(I)} + HR_{k_j}^{(R)} \cdot t_{k_j}^{(R)} \right), \tag{1}$$

subject to

$$\sum_{j=1}^{n} \left(t_{k_j}^{(I)} + t_{k_j}^{(R)} \right) \leq TD, \text{ and} \tag{2}$$

$$t_0^{(I)} \leq t_{k_j}^{(I)} < 0, \text{ for } j = 1, \ldots, n, \tag{3}$$

where k_j determines the j-th interval of the selected k-th interval training session from the archive A, TD is the duration of the interval training (typically ≤ 60 min), and $t_0^{(I)}$ the maximum duration of the high-intensity interval that cannot be zero.

Problem definition 2/2

Objective function is expressed as:

$$f(IT) = |TRIMP(IT) - TRIMP_0|. \tag{4}$$

The task of the optimization algorithm is to find the minimum value of the objective function, in other words:

$$f^*(IT) = \min f(IT). \tag{5}$$

Experiments and results

The aim of the experimental work was to evaluate the proposed stochastic population-based nature-inspired algorithm for planning interval training sessions. In line with this, two scenarios were defined:

- scenario A: deals with interval training of low-intensity *TRIMP*,
- scenario B: deals with interval training of high-intensity *TRIMP*.

Table: Parameters setting of the BA.

Parameter name	Value
Population size Np	50
Individual size n	10
Pulse rate r_i	0.5
Loudness A_i	0.5

Table: Part of the archive.

ID	$HR_{\mathrm{ID}}^{(I)}$	$t_{\mathrm{ID}}^{(I)}$	$HR_{\mathrm{ID}}^{(R)}$	$t_{\mathrm{ID}}^{(I)}$
1	185	5	147	3
2	186	5	148	2
3	186	4	149	2
4	187	5	148	3
5	188	4	150	2

Scenario A

Table: Generated interval training plan of lower-intensity *TRIMP*.

ID	$HR^{(I)}_{\mathrm{ID}}$	$t^{(I)}_{\mathrm{ID}}$	$HR^{(R)}_{\mathrm{ID}}$	$t^{(I)}_{\mathrm{ID}}$	$TRIMP^{(I)}_{\mathrm{ID}}$	$TRIMP^{(R)}_{\mathrm{ID}}$	$TRIMP_{\mathrm{ID}}$
1	183	5	140	2	915	280	1,195
2	187	3	161	1	561	161	722
3	188	3	161	1	564	161	725
4	184	3	160	1	552	160	712
5	187	3	161	1	561	161	722
6	186	5	148	2	930	296	1,226
7	183	5	140	2	915	280	1,195
8	188	3	161	1	564	161	725
9	188	4	150	2	752	300	1,052
10	188	3	161	1	564	161	725
$\sum$	186.2	37	154.3	14	6,878	2,121	8,999

Scenario B

Table: Generated interval training plan of higher-intensity *TRIMP*.

ID	$HR^{(I)}_{\mathrm{ID}}$	$t^{(I)}_{\mathrm{ID}}$	$HR^{(R)}_{\mathrm{ID}}$	$t^{(I)}_{\mathrm{ID}}$	$TRIMP^{(I)}_{\mathrm{ID}}$	$TRIMP^{(R)}_{\mathrm{ID}}$	$TRIMP_{\mathrm{ID}}$
1	179	5	120	6	895	720	1,615
2	188	5	151	2	940	302	1,242
3	178	6	148	3	1,068	444	1,512
4	174	8	138	4	1,392	552	1,944
5	186	4	143	2	744	286	1,030
6	172	9	131	5	1,548	655	2,203
7	185	4	145	2	740	290	1,030
8	177	7	135	4	1,239	540	1,779
9	186	5	148	2	930	296	1,226
10	187	5	148	3	935	444	1,379
$\sum$	181.2	58	140.7	33	10,431	4,529	14,960

Implications in real-world

- Automated planning of interval training sessions can be integrated into Artificial Sport Trainer.
- Artificial Sport Trainer should balance the amount of interval training sessions with other types of activities, e.g. endurance and relaxation.
- Automatically planned interval training sessions from Artificial Sport Trainer were given to real sports trainers who verified the robustness of this method.
- One amateur athlete volunteered to participate in an Artificial Sport Trainer interval training program; his performance and strength are regularly examined.

Conclusion

- Stochastic population-based nature-inspired metaheuristics are a robust tool for planning the training sessions.
- We investigated the possibility of planning the interval training sessions.
- Algorithm for planning the interval training sessions could be implemented by any stochastic population-based nature-inspired algorithm.
- The results confirmed our assumption that population-based metaheuristics can be applied for such type of planning.
- Future work: we would like to consider more information about the past (realized) training sessions.