quickly avoided. In most cases, there is a spike to $H = 1$ when an obstacle is sensed, since we related H to α, which leaps from 0 (in the safe context) to a value greater than β, as soon as the obstacle is detected. An exception is D (brown), where, because of the potential field minimum, H increases gradually. Since 3 obstacles have been detected only for C, we have shown, in Fig. 6, ω, e, φ and $\dot{\varphi}$ during navigation in this scenario. Since we have set $v = \hat{v}$ throughout replaying, the primary task error on $s_{1,2}$ is null, and plotting v is unnecessary. In the graphs, we have highlighted in yellow the iterations, with strong $H \neq 0$. At iteration 15, the purple obstacle is detected: the obstacle vector field induces an abrupt rotation on the robot (green in Fig. 6), and on the camera. The strategy proves efficient since the consequent image error increase is slight (approximately 30 pixels, black in the figure) and is reduced as the robot overtakes the obstacle. Both velocities are almost zeroed, until iteration 280, when the gray obstacle triggers a positive robot rotation and negative pan velocity. Finally, H is activated by the detection of the cyan obstacle. In this case, the robot angular velocity is negative, whereas the camera velocity is positive. From iteration 700 onwards, the activation function is canceled. Correspondingly, the variables are driven by (14). Note also that the camera angle (blue) is reset to 0 in less than 100 iterations, and remains null until the end of the experiment.

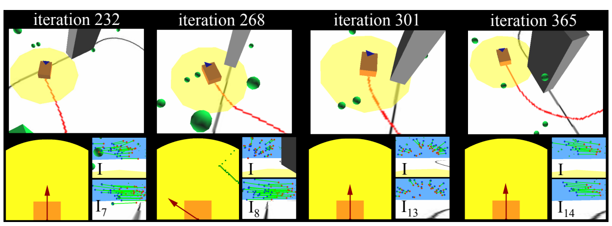

Fig. 4. The robot overtakes the gray obstacle in scenario A. For each iteration we show: the occupancy grid (bottom left), and current and next key image (bottom right).

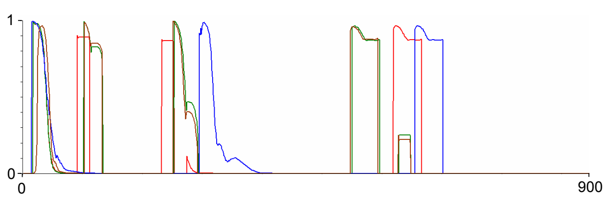

Fig. 5. Obstacle activation function H during simulations in the four scenarios A (red), B (green), C (blue) and D (brown).

VI. CONCLUSIONS

We have applied a redundancy-based approach to the problem of visual navigation with obstacle avoidance. Our approach is novel in appearance-based navigation: it merges techniques from potential fields, redundancy and visual servoing to tackle a sensor-based problem. Simulations are successful in various situations, and in future work, we plan to assess the controller on a real robot.

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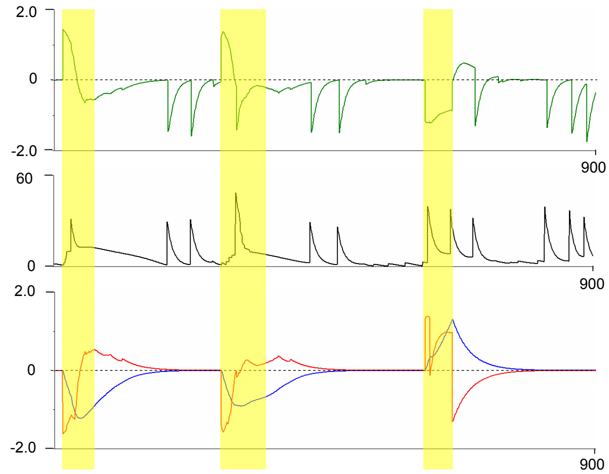

Fig. 6. Evolution of relevant variables during navigation in scenario C: ω (green, in rad s^{-1}), image error e (black, in pixels), φ (blue, in rad) and $\dot{\varphi}$ (red, in rad s^{-1}). The iterations with non-null H are highlighted in yellow.

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