

(12) **United States Patent**
Hourtash

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(54) **SYSTEM AND METHODS FOR MANAGING MULTIPLE NULL-SPACE OBJECTIVES AND SLI BEHAVIORS**

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(71) Applicant: **INTUITIVE SURGICAL OPERATIONS, INC.**, Sunnyvale, CA (US)

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(72) Inventor: **Arjang Hourtash**, Santa Clara, CA (US)

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(73) Assignee: **Intuitive Surgical Operations, Inc.**, Sunnyvale, CA (US)

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(51) **Int. Cl.**

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(57) **ABSTRACT**

Devices, systems, and methods for providing commanded movement of an end effector of a manipulator concurrent with a desired movement of one or more joints of the manipulator according to one or more consolidated null-space objectives. The null-space objectives may include a joint state combination, relative joint states, range of joint states, joint state profile, kinetic energy, clutching movements, collision avoidance movements, singularity avoidance movements, pose or pitch preference, desired manipulator configurations, commanded reconfiguration of the manipulator, and anisotropic emphasis of the joints. Methods include calculating multiple null-space movements according to different null-space objectives, determining an attribute for each and consolidating the null-space movements with a null-space manager using various approaches. The approaches may include applying weighting, scaling, saturation levels, priority, master velocity limiting, saturated limited integration and various combinations thereof.

(52) **U.S. Cl.**

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(58) **Field of Classification Search**

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31 Claims, 23 Drawing Sheets

