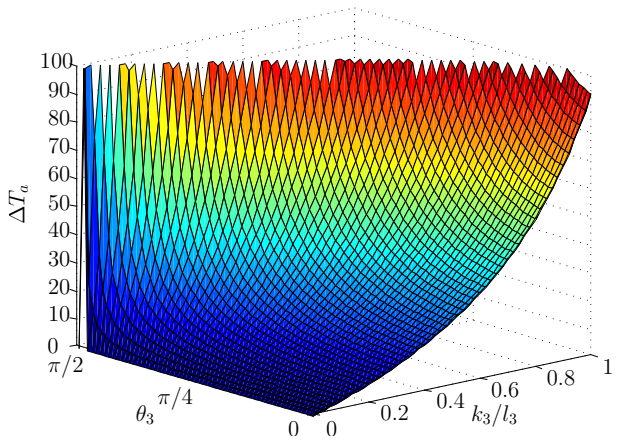

Fig. 8. ΔT_a as a function of the contact location during the final phase

Setting the factor in front of ΔT_a equal to zero, one obtains:

$$b_3 = \frac{X_{a,3} l_2 \cos\theta_3}{X_{a,2} - X_{a,3}}. \tag{31}$$

Beyond b_3, which is a function of θ_3, the finger is completely rigid and no motion is possible. Thus, as the input torque T_a increases, only the contact force magnitude $\mathbf{f}_3$ changes to keep the static equilibrium. It should be noted that the finger is completely rigid no matter the contact location if it occurs on the final phalanx when θ_3 is equal to $\pi/2$.

F. Discussion

As with any theoretical modeling of a physical phenomena, there is always a gap between the simulation results and reality. However, as shown in [9], even if undesired effects such as hysteresis and friction are present, the stiffness variations are typically still measureable. Both contact detection and localization were possible. It also appears reasonable to think that these effects would be less significant in tendon-driven fingers than in compliant linkage-driven fingers as used in [9]. Moreover, the addition of position sensors in the interphalanx joints would also provide redundancy and make it easier to compute the Jacobian matrix in real time. Thus, the relationship between the contact location and the input torque variation is expected to be more robust to noise and other inaccuracies. The geometrical parameters of the finger could also be optimized to reduce the blind zones on the phalanges and improve the precision of the algorithm by increasing the ΔT_a variation. Therefore, many possible avenues exist to improve the algorithm relating the contact location to the input torque variation.

IV. CONCLUSIONS

In this paper, a stiffness analysis of double tendon underactuated fingers was presented. It was followed by numerical simulations providing new insights on the effect of several design parameters on the finger stiffness. From the previous analysis, it can be demontrated that a contact localization algorithm can be obtained from Eq. (20). Future work will center on the application of this method on an experimental prototype.

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